LOSSES IN AGRICULTURE

A Preliminary Appraisal for Review

AGRICULTURAL RESEARCH SERVICE
UNITED STATES DEPARTMENT OF AGRICULTURE
in cooperation with
OTHER DEPARTMENTAL AND FEDERAL AGENCIES

June, 1954

ARS-20-1

FOREWORD

The Department of Agriculture, from time to time, receives requests for information on the losses incurred in the production of crops. In response to these requests, the Research Administrator, in June 1953, appointed a committee to survey this subject. The committee undertook to work up as reliable and well-documented estimates as possible on current losses to agriculture from insects, diseases, fire, erosion, floods, etc., especially losses that might be controllable through more general application of methods already known or methods that might be worked out by additional research.

This report includes such information as the Department now has on the average annual losses to agriculture incurred during recent years, especially the period 1942 to 1951. The estimates are necessarily incomplete, since no opportunity was given for undertaking any special field surveys to obtain new data. They represent the best judgment of the Department specialists on crop and forest production, soils and soil conservation, livestock and animal products, and agricultural economics.

The summary indicates that such losses, evaluated at 1942-51 prices, averaged about 13 billion dollars' worth of goods per year, nearly one-third of the potential production. Some 120 million fewer acres of cropland (ignoring pasture and range requirements) would have produced the 1942-51 volume of food, feed, and fiber production if all these causes of loss had been eliminated.

The committee points out that the dollar valuation assigned to these losses is not to be interpreted as meaning the financial loss to the farmers themselves resulting from the damages described. The committee gave no consideration to the price reductions that might have resulted from the larger crops that could have been produced if these losses had not been incurred. The only reason for placing a dollar valuation on these losses is that the financial value of the quantity destroyed or injured is the only common measure that could be used. The dollar figures represent the Department's evaluation of the losses incurred by the general public at the price levels of 1942 to 1951.

The specialists who made the estimates stated that many of them represented only the individual judgment of the staff members with little scientific or survey data as a basis. Accordingly, the report is issued for review by experiment station staffs and others interested. It is released to the public with the caution that future estimates may modify the figures very materially.

B. T. Shaw
Research Administrator
Agricultural Research Service

This report has been prepared by a committee appointed by the Research Administrator early in 1953. The committee included representatives of the agencies which regularly collect information concerning the extent of losses and damage in agriculture or which otherwise have information about the subject.

The membership of the committee was as follows:

R. P. Christensen (ARS)	C. E. Kellogg (SCS)
Faith Clark (ARS)	P. L. Koenig (AMS)
G. J. Haeussler (ARS)	H. W. Schoening (ARS)
V. L. Harper (FS)	C. F. Speh (ARS)
H. R. Josephson (FS)	M. G. Weiss (ARS)

S. B. Fracker (ARS), Chairman
E. L. LeClerg (ARS), Alternate Chairman

The Fish and Wildlife Service of the Department of the Interior courteously furnished much of the information concerning agricultural losses from rodents, game, and wildlife of various kinds.

CONTENTS

GUIDE TO TABLES

CHAPTER I. INTRODUCTION

It is generally recognized that agriculture and agricultural resources are subject to numerous hazards. Losses occur throughout the production, marketing, and processing of plants, animals, and their products. Diseases and insects reduce the yield of crops, forest trees, and livestock. Crop response is also adversely affected by hail and weeds. Improper land utilization is known to result in enormous deterioration of soils.

Losses in agriculture are of two types - (1) reduction in quantity or deterioration in quality during the production, handling, and processing of farm and forest products, and (2) deterioration in land on farms and forests, affecting annual production immediately in some cases, and over a period of years in the future.

This report provides information concerning the extent of these losses. Losses in the Nation's kitchen are also included to complete the picture of what happens to agricultural products from the soil to human consumption. The report does not include losses in production and productive efficiency due to failure to use recommended management practices, such as the use of farm land for less productive crops than others that might have been chosen.

The Department previously has made estimates of some of the hazards to which agriculture is subjected. However, never before have comprehensive estimates been assembled in one document. The last fairly complete summary of the losses caused by insects was issued by the Bureau of Entomology and Plant Quarantine in 1938. The economic consequences of animal diseases, parasites, and insects were tabulated in the Yearbook of Agriculture for 1942. These were followed by a brief résumé of insect depredations in the Yearbook for 1952. The Yearbook for 1953 covered the effect of plant diseases in general.

The potentialities for obtaining additional and more efficient farm production over the next 4 or 5 years from improved methods and the use of additional fertilizer, lime, machinery, and other resources and at the same time maintaining and improving the productivity of our land resources were evaluated recently in a nationwide study by the U. S. Department of Agriculture in cooperation with the land-grant colleges.1/ The losses described in the present report do not duplicate the field covered in that study.

1/ Land Grant College - Department of Agriculture Joint Committee on Agricultural Productive Capacity. Agriculture's Capacity to Produce - Possibilities Under Specified Conditions. U. S. Dept. Agr., Inf. Bul. 88, June 1952.

CHAPTER II. ECONOMIC CONSIDERATIONS

Economic Effects

Losses in agricultural production have two kinds of economic effects - (1) increased cost of production, and (2) reduced quantity and quality of products available to the consumer. Because of the depredations caused by insects and diseases, crop yields are reduced, and more land and labor must be used to provide our requirements. Furthermore, production costs are higher. From another viewpoint, consumer needs could be more fully satisfied and better nutrition provided with the same resources and expenditures if the causes of loss were not present.

The possibility of profitably reducing or eliminating losses in agricultural production are influenced by technological developments. Technological improvements may affect costs of control or they may influence the value of the products. The discovery of more effective or lower cost insecticides and fungicides, for example, may make possible larger production of higher quality goods with little or no increase in cost to the farmer, or it may make possible the same production with the use of fewer resources and at a lower cost. Similarly, the discovery of new or improved uses for products may increase their total value with little or no change in resources used or in production costs. Regardless of whether costs of production are reduced or the value of the products is increased, these discoveries and their application result in economic gains for the consuming public and generally for farmers.

Some methods of reducing or eliminating losses may require little or no additional operating cost. For example, while development of a new and valuable insecticide or fungicide may originally require substantial funds for research, the new pesticide may be no more expensive to manufacture and apply than those previously used.

Other losses may be much more difficult to reduce or eliminate. For example, it may be impossible to find ways of completely eliminating losses to crops caused by some insects and diseases. And even if it were possible, the cost of control might be high in relation to the additional quantity or improved quality of the crop. Similarly, it may be extremely difficult to find economic uses for all byproducts and materials which presently have little or no value. Methods might be developed for utilizing them, but costs of processing and manufacture might be very high in relation to their final value.

Classification of Losses

It is apparent that losses vary greatly in their causes and effects. A useful classification is as follows:

(1) Losses that are unpreventable with present technological knowledge. There may not be any known way of completely preventing reductions in crop yields caused by certain diseases and insects. Similarly, there may be no known use for certain byproducts or materials.

(2) Losses that are presumably preventable, but only through the use of control measures that are not economically feasible with present technical knowledge and under current economic conditions. It may be possible to prevent the reduction in certain crop yields due to some insects or diseases by applying sufficient pesticides at the required times, but it may not pay the farmer to do so because the cost would exceed the additional value of the product.

(3) Losses that are preventable with present technical knowledge and under current economic conditions. It is possible to minimize or prevent some reductions in crop yields caused by insects and diseases by proper control measures, and it also is profitable for farmers to use such measures. But frequently they may not do so because they lack knowledge of recommendations or have no funds to pay the additional operating costs or to make the necessary capital investments.

With the accumulation of new technical knowledge resulting from research, losses that formerly were not physically preventable may become so. They also may become economically preventable.

Changes in economic conditions may make it economically feasible to prevent losses from certain causes. For example, expansion in market demand and higher prices for farm products would make it profitable for farmers to put into effect certain control measures which previously were not profitable. Similarly, reduction in prices paid by farmers for materials required for preventing losses would make additional control measures profitable. The costs of fertilizers and lime are directly related to problems of soil conservation.

It is recognized that only part of the causes of loss could be prevented even if present technological knowlege could be fully put into effect. Some of the factors preventing full utilization of the most advanced agricultural techniques are - (1) adverse weather, preventing spraying and similar control operations at the proper time; (2) natural inertia of some producers and handlers to adopt the most effective protective measures; (3) nonavailability of pesticides, proper equipment, or seed of resistant varieties; (4) competition with other farm operations, which often delays the use of control measures until after the most effective time; (5) some control measures involve too much equipment, labor, or expense to be profitable under present economic conditions; and (6) lack of knowledge of the most effective protective measures, a difficulty that can be overcome only through an increased educational program.

The extent to which losses in agriculture can be prevented through the utilization of known technical information has not been examined in a comprehensive manner. However, certain specific hazards have been analyzed.

Losses from diseases of cotton could be reduced by about 75 percent with complete and adequate seed treatment, full use of known and adapted resistant varieties, proper application of soil-deficient elements, and proper practices for control of soil-borne organisms. It is estimated that losses from apple diseases could be reduced one-half (from 6 percent to 3 percent) if all producers would use recommended control procedures, and if weather permitted their efficient use. If all growers made the fullest possible use of all the measures now recommended for control of potato diseases, it is estimated that the present losses might be reduced about 50 percent. By use of appropriate control methods for diseases of wheat, the losses could be reduced an estimated 23 percent. With tobacco a slightly greater saving, 29 percent, is estimated to be possible by proper disease prevention.

About one-third of the losses in weight gains of animals and milk production could be averted by the intelligent use of modern insecticides. The application of known control measures, namely, chemoprophylaxia and sanitation, could reduce the loss caused by coccidiosis of chickens and turkeys about 90 percent. Procedures developed by research, when properly applied in the field, make it possible completely to eradicate brucellosis in cattle, swine, and goats.

Benefits of Improved Technology

Considered historically, research to find ways of making losses in agriculture physically and economically preventable and educational work to get them adopted have made great contributions to the welfare of farmers and the public generally. If it were not for research discoveries and their application to farming, the cost of producing farm and forest products now would be much higher, the output would be less, and levels of consumption might be lower.

Looking ahead, national requirements for agricultural products to provide for a growing population and improved levels of living may be expected to increase greatly. Projections of population growth made by the U. S. Bureau of the Census indicate that total population is likely to increase 10 percent by 1960 and nearly one-third by 1975. If large additional requirements for farm and forest products are to be met at prices to consumers that will allow continued improvement in levels of diet, it will be necessary to find ways of expanding output without higher costs of production.

Further progress in finding ways of preventing losses, as in the past, will have two desirable economic effects - (1) increased total production of farm and forest products and (2) reduced costs of their production.

The fact that market outlets for agricultural products are expected to expand gradually means that additional production resulting from the prevention of losses need not depress prices or reduce gross incomes of producers over a period of several years in the future. With adequate attention to research and education they could contribute much to expanding requirements for products over a period as far ahead as 1960, or 1975.

Moreover, in situations where supplies of agricultural products are relatively large and farm prices have declined, there is special need to put increased emphasis on finding ways of controlling losses at lower costs to farmers. This could be an important way of helping to maintain and improve net farm incomes. Discovery of new uses for products and ways of reducing costs in marketing and distribution by better control of losses in marketing channels also would improve net farm incomes.

Other Means of Improving Production

As mentioned in Chapter I, there are ways of expanding production and reducing costs of farm and forest products other than the more effective control of the specific losses covered in this report. For example, production could be expanded and costs reduced by wider use of technological improvements, such as better kinds of plants and livestock. Obviously, it will be desirable to take advantage of all the opportunities for making agricultural production more efficient and of obtaining additional production when needed at the lowest possible costs.

The study of agriculture's capacity to produce that was cited in footnote 1, Chapter I, indicated that a total farm output 20 percent greater than in 1950 could be attained within the next 4 or 5 years, if necessary, by means other than the control of the kinds of losses to which this report relates. That projection was based on the assumptions that weather would be average throughout the period; that price and income incentives would be sufficient to encourage higher production; that additional quantities of fertilizer, machinery, and other requisites would be available at costs that would encourage increased use of them; and that educational and operational programs would be redirected to speed up adoption of improved farming practices. The study was not a forecast of what farmers will do, but rather an estimate of the production level they could attain under such favorable conditions. It also indicated that considerable progress toward widespread adoption of conservation systems of farming would be possible, with consequent establishment of a basis for continuing abundant farm production.

CHAPTER III. PROCEDURE

Nature of Estimates

Estimates of losses are included in this report, whether or not they arise from causes that are preventable with present technical knowledge. It has not been possible, however, to obtain complete estimates of all such losses.

The loss estimates are limited to the more important factors and include:

(1) Diseases and insects affecting field, forage, fruit, nut, vegetable, and drug crops, pastures and ranges, and ornamental plants (Chapters IV and V).

(2) Mechanical injuries, weeds, and hail damage to crops, and fire and brush damage to grazing and range lands (Chapter VI).

(3) Mechanical deficiencies in harvesting field crops, and rodent and insect damage during storage of crops or their products (Chapter VII).

(4) Losses in marketing, processing, and distributing agricultural crops (Chapter VIII).

(5) Fire, wind damage, insects, and diseases affecting forest growth and forest trees (Chapter IX).

(6) Diseases, internal parasites, and insects affecting livestock (Chapter X).

(7) Erosion and other causes of deterioration of crop, forest, and range lands and damage to watersheds from floodwater and sediment (Chapter XI).

Losses in quantity as well as quality and losses to land are included. The land losses, of course, affect production over a period of several years.

Other sources of loss are recognized, although detailed estimates could not be made of them. They are discussed in Chapter XII, and include (1) loss of calories and other food values due to the discard of edible portions of food in the kitchen or to destruction of nutrients in cooking, (2) losses caused by birds feeding on agricultural crops, and (3) the labor and materials involved in the control of pests and other factors.

Computation of Losses

Most of the losses are expressed as annual production lost in terms of (1) quantity, (2) value, and (3) equivalent acreage. Quantitative estimates of losses, in bushels, tons, etc., indicate the extent to which

national production would have been increased had the cause of the loss been eliminated. Estimates of value indicate the loss in dollars at the average prices received by farmers. The estimates of acreage equivalents represent the acreage that could have been saved if the loss had not occurred.

The losses shown in the tables are based on national annual averages chiefly for the 1942-51 period. Because of wide variations in some kinds of losses from year to year, it was considered desirable, where possible, to use an average for the 10 years rather than a single year. In some instances, as pointed out later, lack of information on which to base estimates for the 10-year period made it necessary to use a shorter and more recent period.

The manner in which estimates were computed can best be explained by the use of examples. Reductions in annual quantity of marketable crop production on farms may be considered first. In the case of insects and diseases attacking crops, estimates were made of percentage losses from potential production. Let us assume that the estimated loss from full production was 20 percent and that actual production was 400 million bushels. Total production with the cause of loss eliminated would have been 500 million bushels. The quantity loss is 100 million bushels (or 20 percent of 500 million bushels), and is equivalent to 25 percent of the quantity actually harvested (400 million bushels). The loss in value of production was computed by applying the loss percentage in the same manner to the value of the crop. The acreage equivalent of the loss is 20 percent of the actual acreage, because had there been no loss the actual production could have been obtained on 20 percent fewer acres.

Estimates of losses from deterioration in quality of crops produced on farms are included in the computation of losses in value and in the acreage equivalent of lost value described above. For example, if it were estimated that because of certain diseases affecting quality the total value of a crop was 20 percent lower than it would have been without this damage, the potential value of the crop would have been 25 percent higher than it actually was. The acreage equivalent of the damage is 20 percent of the acreage used to produce the crop. This means that had there been no reduction in quality the actual value of this crop would have been produced on 20 percent fewer acres.

Losses to crops while in storage on farms and to crops, including fruits and vegetables, in marketing channels also were measured in terms of quantity and value lost, and where possible in acreage equivalent of lost value. Farm quantities, values, and acreages are multiplied directly by loss percentages to obtain the three measures of average annual losses. In the case of crops stored on farms the acreage to which loss percentages are applied is the equivalent acreage obtained by dividing the quantity stored by average annual crop yields. The acreage to which loss percentages in marketing channels and processing are applied is that required to produce the quantities marketed or processed, assuming the same average yields as for the entire production.

Losses in production of livestock products on farms due to diseases and other causes are expressed in terms of quantity and value obtained by the procedure described for crops. However, the acreage equivalent of lost value for individual diseases was not computed and only a consolidated estimate of the acreage equivalent of livestock losses is made.

Some losses have not been expressed in terms of annual production lost. For example, reductions in productivity of land and other physical capital due to erosion and other types of soil deterioration are expressed as annual average quantities and value of resources lost.

How Estimates Were Obtained

Estimates of losses are based on statistical surveys and records wherever possible. However, they were not available for many causes, and it has been necessary to rely upon judgment estimates made by specialists in the different natural science fields. But even the information that these specialists have available is limited; consequently, the accuracy or reliability of the estimates differs greatly.

Each member of the committee served as a leader of a group within his agency, which assembled the estimates obtained from specialists. Most of the estimates were made in such a way as to be applicable to national data on production and resources. About 750 individual loss reports on separate commodities and due to separate causes of loss were prepared by about 100 specialists in the Department, and they were assembled and grouped according to causes and kinds of production affected.

Adding estimates of losses from different causes affecting the same product in such a way as to avoid duplication or overestimating presented a special problem. It was assumed that percentage loss estimates could be added when they were low and from closely related causes, such as diseases affecting the same crop. However, it was frequently necessary to combine estimates from several different causes affecting the same product into a single estimate. This was done in consultation with the specialists who submitted the original estimates and the consolidated totals are considered conservative.

The Agricultural Estimates Division of the Agricultural Marketing Service supplied data on national acreage, quantity of production, farm value of production, and other basic data against which loss estimates were applied to obtain national estimates. This Division also performed most of the computations necessary in summarizing estimates and made certain checks to see that estimates were mathematically consistent.

Meaning of Estimates

In interpreting estimates of losses shown in this report, it is essential to recognize the assumptions on which they are based.

The estimates indicate not only preventable reductions in production, but also those that are not avoidable with present technical knowledge.

Additional resources would be needed and additional costs incurred to reduce these losses. For example, additional labor, machinery, and materials would be required to put control measures into effect and also to complete the production process in the case of losses that occur before harvest or production otherwise is completed. This would also be true of the estimates of losses to land.

The estimates evaluate the annual production and land resources lost at the prevailing average farm prices. This does not necessarily mean that the farmers' cash income would have been increased to that extent if the losses had not been incurred. Increased supplies sometimes cause sufficient price decreases so that the total farm income from a large crop may be no greater than from a small one. The loss from the destruction of food supplies, however, is just as serious from the standpoint of the American public whether price changes result or not. The losses given must therefore be interpreted as losses to the general public rather than to the farmer. It would not be possible immediately to sell greatly increased quantities of products except at lower prices, but markets can be expected to expand considerably in the next 25 years with continued population growth accompanying general economic growth.

The original computations were carried out to more significant places than are shown in the tables. This may explain occasional apparent slight discrepancies in the loss percentage and acreage equivalent figures as tabulated.

Acreage Equivalents

The acreage equivalents shown in the last right-hand columns of many of the tables in this paper indicate the number of acres that were required to produce that part of the crop that was lost from the cause shown. Each such estimate takes into account conditions on each crop separately. It thus is based on the average returns from the crop on the class of land on which that crop was grown, and the potential production that would have occurred if that particular cause of loss had not been present.

In the Summary (Chapter XIII) the losses from all causes, expressed in dollars as a convenient measure, are added together and an over-all acreage equivalent on an average loss basis is computed from the percentage relationship that the estimated loss bears to the potential total agricultural production of the United States--the production that would have occurred if none of the causes of loss had been present in the production and distribution of any of the materials concerned. This method averages out all differences in returns-per-acre and losses-per-acre between different crops, and gives a lower acreage equivalent of loss than the sum of the individual items. That equivalent is a very conservative estimate of the total number of acres whose product is lost annually due to the causes discussed in this report.

One reason for the difference between the total of the acreage equivalents in the tables and the over-all equivalent given in the Summary is that the separate equivalents cannot reflect the interaction between different causes of loss, that is, the effect that such causes have on each other. This may be illustrated by a hypothetical simplified example of an area in which 1,000 acres were devoted to cereal production.

Assume that the actual harvest brought a return of $50,000 after estimated losses of $30,000 from diseases, $15,000 from insects, and $5,000 from weeds. If each is considered independently, the data may be tabulated as follows, duplicated values being enclosed in parentheses:

Cause of Loss	Production: Area	Production: Value	Losses: Percentage	Losses: Value	Losses: Acreage Equivalent	Losses: Per Acre
	Acres	Dollars	Percent	Dollars	Acres	Dollars
Diseases	1,000	50,000	37.5	30,000	375	30
Insects	(1,000)	(50,000)	23.1	15,000	231	15
Weeds	(1,000)	(50,000)	9.1	5,000	91	5
Sums	1,000	50,000	----	50,000	697	50

The acreage equivalent in each case represents the number of acres that would not have been needed if the particular source of loss had not been present. That is, if only plant diseases could have been eliminated without affecting the other two causes of loss, 375 acres could have been saved, and the actual $50,000 return could have been expected as the income from the remaining 625 acres.

The sum of the three equivalents is 697 acres if they are considered independently.

However, if no disease was to be anticipated and only 625 acres had been planted to the disease-free crop, insect damage, at $15.00 per acre, would have amounted to only $9,375 instead of the $15,000 shown in the table. The potential return would have been $59,375 (that is, $50,000 plus $9,375), and the insect loss percentage would have been 15.79 percent. This gives an acreage equivalent of 98.68 acres (that is, 15.79 percent of 625 acres).

Reducing the acreage by another 98.68 leaves 526.32 acres as all that would have been needed if both diseases and insects had been avoided. At $5.00 per acre, the loss from weeds on this reduced acreage would have amounted to $2,631.60. This gives a loss percentage of 5.0 percent (that is, $2,631.60 ÷ $52,631.60). The acreage equivalent would be 26.32 acres.

The total acreage equivalent, allowing for interaction, would thus be 375 + 98.68 + 26.32 = 500 acres.

A more expeditious method of computation to allow for interaction, and all other complications, was employed in the over-all Summary. It will be noted in the above example that the sum of the losses totals $50,000 which is 50 percent of the potential return of $100,000 (that is, $50,000 + $30,000 + $15,000 + $5,000). 50 percent of the original 1,000 acres is 500 acres, the acreage equivalent of the combined losses with allowance for interaction. This agrees with the above more detailed analysis.

The inclusion in this report of crops with different yields, and of losses incurred in storage, distribution, and feeding, in addition to those during production, introduces further complications in the interpretation of the acreage-equivalent figures. However, the principles and the type of interpretation used in the above illustration are applicable to many elements in the picture.

Extending this interpretation to the totals in this report, if no losses had been incurred, the actual returns from 1942-51 crops at current prices could apparently have been obtained from 120 million fewer acres than were in fact used by American farmers. The sums of the acreage equivalents in the tables considerably exceed that figure. While correct individually, they are not properly additive, since losses interact in several ways and the individual totals cannot allow for such interaction.

Consolidated Values

The sum of the farm values of all individual farm crops (Tables 1-11) and the annual production of livestock and poultry and their products (Tables 20-28) exceeds the gross return from farm products sold and consumed directly in farm households, because many farm crops are used for animal feeds, and the farmer's cash income to that extent comes from livestock products instead of from crops.

In the Summary, over-all base figures are used that make allowance for this factor. The adjusted annual averages for 1942-51 are as follows:

Cash receipts from farm marketings plus farm value of products consumed directly in farm households:

Crops........................	$11,555,000,000
Livestock and products.......	15,715,000,000

Cropland acreage of harvested crops........................	357,835,000

CHAPTER IV. PLANT DISEASES 1/

In this report only losses attributable to specific parasites such as bacteria, fungi, viruses, and nematodes are estimated. Diseases resulting from nutritional disturbances are included only when corrective measures are normally taken concurrently with control of diseases.

Production statistics and losses to plants by diseases have been grouped by types of crops - field crops, forage crops, fruit and nut crops, vegetable crops, and drug and ornamental crops. Loss descriptions follow for each of the crops in the various groups.

Field Crops

Production statistics and estimated disease losses of the major cereal, sugar, tobacco, and fiber crops appear in Table 1. Estimates of losses to minor crops have not usually been made, as they would not contribute substantially to over-all agricultural losses, and on most of them less information is available.

Barley

The major diseases that attack barley in the United States, causing together an estimated annual loss of 5 percent of the crop, are loose and covered smuts, rust (stem and leaf), powdery mildew, the Helminthosporium diseases (net blotch, spot blotch, and especially stripe), scab, scald, various foot rots, the bacterial diseases basal glume rot and bacterial blight, and virus diseases. The smuts cause the most consistent losses. The viruses are the latest to appear and cause serious damage. Smut, mildew, rust, and Helminthosporium are the most widely distributed. Scab, when it occurs, not only reduces the yield but also impairs the feeding value of the grain for certain classes of livestock. Transmission of the stripe-mosaic virus and loose smut within the seed from crop to crop increases the difficulty of control. Mild attacks of many of the diseases injure the quality (kernel plumpness) of the grain, thus lowering its value for use as malt. It is difficult to evaluate the quality losses, but in some years they are considerable.

Corn

Diseases reduce corn production in the United States by millions of bushels each year. The losses in individual fields often exceed 10

1/ Loss estimates for diseases transmitted by insects are included in this chapter instead of Chapter V.

percent. The diseases also lower the value and quality of the grain and fodder and increase the cost of harvesting when they cause the crop to lodge. In this country corn is subject to about 25 diseases. They attack all parts of the plant--ears, leaves, stalks, and roots--at various stages of development. Average losses for the 10-year period 1942-1951 amount to about 4.8 percent in yield and 0.4 percent in quality. On the basis of the average farm value of the crop for the same 10 years, this loss amounts to about $227 million each year. Losses vary in different sections of the country, being greatest in the more humid sections of the South.

The major diseases of corn are diplodia stalk rot, diplodia ear rot, fusarium ear rot, northern corn leaf blight, southern corn leaf blight, Stewart's wilt, and smut. The two diplodia rots are widespread over most of the Corn Belt and the eastern part of the United States. Fusarium ear rot is a common disease, but often most destructive in the drier areas. Northern corn leaf blight is generally found from Illinois eastward to the Atlantic coast. It becomes severe when the growing season is cool and dews are abundant. This disease was destructive in 1943 and especially in 1951. Southern corn leaf blight extends generally from the Ohio River Valley southward. The disease thrives when dews are heavy, but it is favored by higher temperatures than northern corn leaf blight. Stewart's wilt is most severe on sweet corn, but it may cause appreciable leaf killing on dent corn in some years. It is found chiefly in the central part of the United States from Illinois eastward. Its prevalence and severity increase in growing seasons preceded by mild winters, because such conditions favor the survival of large populations of the corn flea beetle, the vector of the disease. Smut is widespread, but is often most prevalent in the drier areas. The incidence of smut in the eastern half of the country was unusually high in 1945 and 1952.

Frequently one or more of the minor diseases of corn may become destructive in localized areas. Charcoal rot, for example, has been known to cause appreciable injury to the stalks in some western parts of the Corn Belt.

Cotton

On cotton several of the disease organisms attack the plants at various stages of development, with correspondingly different manifestations.

Seedling diseases are caused by a complex of seed-borne and soil-borne organisms. Losses occur across the entire Cotton Belt, but are greatest in the Southeast. Periods of cool, damp weather following planting are especially conducive to losses, which may involve the entire stand. Seedling diseases account for 25-30 percent of the annual disease loss in cotton. The cost of replanting represents only a fraction of the potential loss, inasmuch as replanted cotton may also be damaged from insect attack and from weed competition.

Table 1. Losses Due to Diseases of Field Crops

Commodity and unit of production	Actual production 1/			Loss of production 2/			
	Quantity	Acreage	Value	Percentage	Quantity	Value	Acreage Equivalent due to loss
	1,000 units	1,000 acres	1,000 dollars	Percent	1,000 units	1,000 dollars	1,000 acres
Cotton (fungi and bacteria) (bales)	12,215	22,036	1,737,995	14.5	2,075	294,746	3,195
Cotton (nematodes) "	-	-	-	3.0	378	53,753	661
Cottonseed (tons)	4,955	-	305,640	17.5	1,051	64,833	
Sub-total for cotton		22,036	2,043,635			413,332	3,856
Dry beans (including dry limas and seed beans) (100 lb bags)	16,478	1,918	124,277	11.5	2,141	16,149	220
Dry peas (including seed peas)	5,472	498	25,418	13.0	818	3,798	65
Barley (bu.)	295,299	13,487	326,490	5.0	15,580	17,226	676
Corn "	3,036,380	88,024	4,146,062	4.8 3/	153,094	227,412 3/	4,577 3/
Flax (seed) "	38,312	4,348	147,438	4.6	1,853	7,106	207
Oats "	1,324,614	43,953	981,495	21.3 4/	359,142	302,006 4/	10,342 4/
Rice (100 lb bags)	35,120	1,668	160,922	5.9	2,202	10,090	98
Wheat (bu.)	1,088,548	70,584	1,943,821	6.6 5/	76,547	156,925 5/	5,273 5/
Sub-total for grains	-	222,064	7,706,228	-		720,765	21,173
Hops (lbs.)	51,075	38	29,280	5.0	2,688	1,541	2
Peanuts (exclusive of hay) (unshelled) (tons)	1,031	2,951	186,668	19.0	242	43,787	561
Sorghums (grain) (bu.)	137,263	7,347	160,414	8.3	12,424	14,519	610
" (silage) (tons)	4,540	723		8.3	411		60
" (forage) (tons)	8,500	5,909	107,538	8.3	769	9,733	490
Sorgo (for syrup) (gals.)	7,991	128	11,783	30.0	3,425	5,050	38

Sugar beets	(tons)	10,027	829	104,573	16.9	2,039	21,267	140
Sugarcane	(tons)	6,281	316	37,407	13.5 6/	980	6,862 6/	49 6/
Sugarcane sirup	(gal.)	16,573	91	17,216	8.0	1,441	1,497	7
Sub-totals for sugar crops		-	1,236	159,196	-		29,626	196
Tobacco	(lbs.)	1,948,844	1,677	881,868	23.6 7/	601,999	321,229 7/	448 7/
TOTAL FOR FIELD CROPS		-	266,525	11,436,305	-	-	1,579,529	27,718

1/ So far as possible the basic data represent the averages for the period 1942-51 as estimated by the Crop Reporting Board of the Agricultural Marketing Service. Where data were not available, best approximations were used. Planted acreages are shown in most instances, although in some cases harvested acreages are used.

2/ Estimate of percentage of loss is the loss from full production with the cause eliminated. These percents were applied to the data on actual farm production to obtain estimates of loss of farm production in terms of quantity, value, and acreage equivalent. Reductions in quality of production are included in the value and acreage equivalent, but usually not in the quantity column. Value loss is computed upon the assumption that market outlets would be available for production lost with no change from average farm prices. Acreage equivalent shows the reduction in acreage which would be possible and still produce the actual quantity of production. See Chapter III of text for more detailed explanation of procedure.

3/ Loss in value from corn diseases was estimated at 5.2%.

4/ Loss in value from diseases of oats was estimated at 23.5%.

5/ Loss in value from diseases of wheat was estimated at 7.5%.

6/ Loss in value from diseases of sugarcane for sugar was estimated at 15.5%.

7/ Loss in value from diseases of tobacco was estimated at 26.7%.

Also the delayed harvest may result in lowered grades or frost damage.

Wilts contribute 25-35 percent of the annual disease losses in cotton. Fusarium wilt is confined primarily to the lighter, more acid soils of the Southeast, extending to eastern Texas and Oklahoma. Losses from this wilt have been greatly reduced in recent years through the use of resistant varieties. Verticillium wilt occurs across the entire Cotton Belt, but the greatest losses occur in the Mississippi Delta and in the irrigated areas of the Southwest, particularly the El Paso Valley, Arizona, and California. A close spacing of the plants in the row and cultural or irrigation practices that tend to raise the soil temperature have reduced the losses from this disease. No resistant varieties have yet been developed, but considerable progress has been made in the development of tolerant varieties such as Acala 4-42 and W-29-1.

Phymatotrichum root rot occurs primarily in the black prairie soils of Texas and in the highly calcareous soils of the Southwest. It causes the greatest damage in the black prairie soils. The average annual loss is 8-10 percent of the entire cotton crop. Losses have been greatly reduced through early fall plowing, applications of phosphate fertilizers, and rotations with Hubam clover.

The boll rots are caused by a complex of organisms, many of which are normally considered to be saprophytic, which under appropriate conditions grow on the injured bolls and produce serious damage to the fiber. The estimated annual loss from boll rots is 8-10 percent of the entire crop. No practical measures have been developed for their control, but the practice of defoliating is beneficial inasmuch as removal of the leaves permits circulation of air and sunlight. Excessive late irrigations or unusually heavy applications of nitrogen should be avoided, as they tend to increase vegetative vigor with a resulting increase in shading which favors the development of boll rots.

Minor diseases and mineral deficiencies cause losses each year, but the aggregate probably does not exceed 15 percent of the crop loss. Deficiency diseases are easily controlled by addition of the deficient mineral.

Dry Beans (including seed beans and dry limas)

Losses in dry beans result chiefly from three types of injury. Root rots, caused by various fungi, account for much of the loss wherever the crop is grown. Common bacterial leaf blight causes serious damage in humid sections. Rust frequently causes serious foliage injury, especially in the West. Virus diseases are damaging wherever beans are grown. The major losses are caused by the common bean mosaic virus and that of bean yellow mosaic. The curly top virus damages beans in Utah, Idaho, Oregon, Washington, and California.

Curly top is transmitted by a single species of leafhopper, and its occurrence is limited to the West where the insect occurs. In some areas where the disease and the vector are most prevalent, curly top prevents the production of susceptible crops, including beans.

Losses of seed snap beans are caused chiefly by root rots and virus diseases. Rust has not caused much loss in the seed crop, and bacterial blights are less severe because most of this crop is grown in the semi-arid West. Halo blight, however, causes some loss. Curly top is responsible for about as much loss as in dry beans. Baldhead, which results from threshing injury, also causes considerable loss in seed beans.

Root rot can be controlled to some extent by chemical seed treatment and crop rotation. Bacterial blight losses are reduced by using seed produced in the dry areas of the West where blight is not epidemic. Losses from rust can be greatly reduced by dusting with sulfur. There are a number of bean varieties resistant to common bean mosaic and some field bean varieties resistant to curly top. As yet we have no varieties resistant to bean yellow mosaic.

Losses in dry lima beans are caused chiefly by the root rots affecting dry beans and seed beans.

Dry Peas (including seed peas)

Losses from disease in dry peas and seed peas are due principally to root rot. Less severe losses are caused by ascochyta leaf spot, bacterial blight, powdery mildew, and mosaic viruses.

Root rots are difficult to control because the organisms persist in the soil, but crop rotation tends to prevent losses from becoming more severe each year. Use of clean western-grown seed treated with a fungicide helps to reduce loss from ascochyta and bacterial leaf blights. Virus diseases are not controlled.

Flax

Rust, pasmo, and wilt are the important flax diseases in the United States. Anthracnose seedling blight and heat canker are also rather widely distributed and occasionally cause losses. The prevalence and destructiveness of the diseases vary from season to season, depending on weather conditions and, with rust, on the prevalence of races of the disease organism that may attack varieties widely grown.

Losses from rust averaged 3 percent during the 10-year period and were rather high in 1943, 1950, and 1951. Losses vary greatly from year to year, usually being worse in years of heavy rainfall. Rust causes a reduction in yield and in quality of the flax seed and fiber.

New pathogenic races of flax rust have been responsible for the precipitous rise and fall in the popularity of flax varieties. During the last 20 years losses due to flax rust have ranged from 0.5 to 10 percent, or from $200,000 to $12,000,000. A rapid build-up of races attacking Bison resulted in heavy losses in the North-Central States in 1941, 1942, and 1943. By 1944 rust-resistant varieties had replaced most of the Bison, and rust losses were of minor importance. Races attacking Dakota, a variety grown throughout the North-Central States, were discovered in the Red River Valley of Minnesota and North Dakota in 1948. These new races spread so rapidly and caused such damage in 1950 and 1951 that by 1952 rust-resistant varieties had superseded Dakota in the main seed-flax-growing area of Minnesota, North Dakota, and South Dakota, and losses due to rust were small.

Losses from pasmo have not exceeded 1 percent of the total flax crop except in 1943, when the loss was estimated at 5 percent. Pasmo usually does not infect the plant heavily until it is approaching maturity. It is prevalent throughout the flax-growing area, but is more severe in southwestern Minnesota, southeastern North Dakota, and eastern South Dakota.

Wilt was formerly a very destructive disease throughout the flax-growing area of the North Central States, but in this area during the 10-year period losses did not exceed 1 percent in any year as a result of the growing of resistant varieties. It was more destructive in Minnesota and eastern North and South Dakota. Losses from stunting and premature ripening due to wilt may vary from 0.5 percent in cool seasons to 2 or 3 percent in warm years.

A number of seed-borne and soil-inhabiting fungi cause seedling blights and damping-off of flax, reducing stands. Seed lots containing many broken or cracked seeds or seeds of weak germination are most subject to damage. Many seed lots respond to treatment. Consequently, loss attributable to seedling blight and damping-off includes the cost of treating the seed, the seed that must be sown to compensate for the reduced stand due to the disease, and the reduced yield due to thin stands. This loss may range from 0 to 2 percent or more each year.

Hops

Downy mildew of hops occurs in Washington, Oregon, California, and New York. Hop culture in New York has been practically eliminated, largely because of the mildew disease. The disease is most critical during periods of high humidity and less serious in the drier valleys of hop production. The diseased leaves and vines are deformed, and hop cones are not formed or are unsalable. The annual losses amount to $1,541,000, or about 5 percent of the total hop production in the country. About 10 percent of the crop in Oregon, 4.5 percent in California, and less than 1 percent in Washington is lost.

Limited control is obtained by the use of dusts and sprays, and their use is absolutely necessary in regions of high humidity. Control measures save some of the crop; however, there are also vine losses which are high because expensive hop-yard structures are not utilized until a new vine can be brought into production 2 years after planting. Dusting and spraying cost about $15 per acre in Oregon, where many applications are required, to a minimum of about $7.50 in areas where the disease is less severe. Although there is some varietal difference in susceptibility to the disease, the type of hop most in demand is susceptible.

Oats

The losses from oat diseases in the United States are generally higher than those from diseases of other small grains, because most of the crop is spring-grown in warm, humid regions usually favorable for disease development. Heavy losses are also experienced in the deep South, where oats are fall sown and the winters are mild and humid. However, less than half of the more than 20 diseases attacking oats in the United States have caused appreciable damage.

Crown rust, the most important disease, occurs throughout the oat-growing areas. It caused an average loss of 5.1 percent to the oat crop in the United States, and losses in Iowa have run as high as 20 percent or more in some years. Individual fields may be a complete loss. Losses vary from year to year, depending on weather conditions and abundance of inoculum of races of the organism that can attack the varieties of oats being grown. Crown rust does not cause damage in the less humid sections of the West. Both yield and feeding quality of the grain are reduced.

The losses from the two Helminthosporium diseases, leaf blotch and Victoria blight, averaged 3.8 percent for the 10-year period, but were very severe in 1946, 1947, and 1948, when varieties susceptible to the latter were being grown. Since that time there has been very little loss. These diseases cause blighting of seedling and adult plants. Production in Iowa was reduced more than 30 percent in 1947.

Septoria black stem of oats first caused appreciable damage in Iowa and other North Central States in 1947. By 1952 it was widespread throughout the more northern States in this region and caused an estimated loss of 15 percent of the Iowa crop.

Stem rust, like crown rust, occurs in the more humid sections and in the more humid years. Losses to individual fields during epidemics may be complete, but the average annual loss is much less than from crown rust. Stem rust was of minor importance after resistant varieties became generally available until the sudden increase in prevalence of race 7 starting in 1949. Race 7 caused heavy losses in Iowa, Minnesota, Wisconsin, and some other States in 1953, reaching 10 percent in Iowa.

Although once of major importance, the oats smuts are now of minor importance owing primarily to the widespread use of resistant varieties. They also can be controlled by seed treatment.

Red leaf, caused by a virus, has caused estimated losses of 3.8 percent for the 10-year period. It stunts the plants with a resulting loss in yield and quality. It is widely prevalent over the United States.

Root and culm rots cause blight of seedlings and root necrosis of adult plants, reducing stand vigor and yield for pasture and grain production. They are prevalent over the oat-growing areas but more severe in humid areas or wet years.

Rice

Rice is grown in the South, especially in Arkansas, Louisiana, and Texas. (Some is also produced in California, but the following account refers specifically to the southern crop.)

Seedling blight, leaf spotting, sterility, and discoloration of the kernel cause heavy losses of rice.

Seedling blight is probably responsible for a reduction in yield of about 2 percent each year. The losses caused by leaf-spotting fungi and by sterility, which is due to early infection of the florets and pedicel, are difficult to estimate but are probably about 2 percent.

Losses from blast have not been great during the past 10 years, because Zenith, which is resistant to the race of the organism prevalent in Arkansas, has been grown in most places where this disease usually occurs. Had a susceptible variety such as Early Prolific or Caloro been grown, losses might have been 2 percent annually in Arkansas alone, and somewhat less in the other southern States. In 1951 and 1952 this disease caused serious damage to the small acreage in Florida. Zenith is susceptible to a race of the blast fungus found in Florida. If this race should spread to other southern rice-growing States, the losses could be greater than for any other disease.

In each of the 10 years approximately 40 percent of the southern rice acreage has been sown to varieties that are susceptible to white tip. In experiments at Stuttgart, Arkansas, effective control of white tip gave an average increase of 17 percent in yield. On the assumption that 25 percent of the acreage of susceptible varieties was reduced in yield as much as were the untreated plots in these experiments, the annual reduction in yield would be about 1.5 percent of the total crop.

Sterility of the type generally called straighthead and a similar injury caused by a toxic concentration of arsenic in the soil cause a loss of about 0.1 percent annually.

Losses from stem rot were less serious in the last 4 or 5 years than in the first part of the 10-year period. The improvement is probably the result of improved rotation, fertilizer, and other cultural practices as well as of the normal variation in severity of the disease. However, each year there are fields where stem rot causes heavy losses. A conservative estimate for the 10-year period would be about 0.1 percent per year.

Reduction of the milling quality and lowering of the grade caused by discolored kernels infected by fungi, stem rot, kernel smut, and white tip are probably responsible for a reduction of 0.5 percent in the value of the rice crop each year.

Peanuts

Most of the losses to peanuts are from two diseases. The more common disease is Cercospora leaf spot, which is very damaging to the leaves and thus weakens the plants. Another fungus disease, southern blight, attacks the roots, stems, and pods. Minor loss is caused by root-knot nematodes. These diseases are prevalent wherever peanuts are grown.

Losses from Cercospora leaf spot can be reduced by dusting the plants with sulfur, but there is no control for southern blight and root-knot nematodes except crop rotation.

Sorghum (including grain sorghum, sorgo, broom corn)

Of the numerous diseases to which sorghum is subject, some of which frequently cause heavy losses, four general types may be recognized - (1) those that reduce stands by rotting the seed or by killing the seedlings; (2) those that attack the leaves and decrease the value of the plants for forage; (3) those that attack only the heads and prevent the normal formation of grain; and (4) those that cause root or stalk rots and prevent the normal development and maturity of the entire plant. The loss from all diseases is estimated at 8.3 percent.

The smuts, which destroy the seeds, cause a reduction in the grain yield of grain sorghums directly proportional to the amount of infection, but in sorgo they reduce the yield of forage or sirup only slightly. In broomcorn, smut may not affect the yield of fiber, but if it is abundant it blackens the brush and lowers its market value.

Leaf diseases are prevalent in most sorghum-growing areas. They cause less reduction in the yield of grain sorghum, but they may seriously impair the production of forage from sorgo in the Gulf and Atlantic Coastal Plains and other humid regions, or in years of heavy rainfall.

Seed rot is most severe when the soil is cold and wet after planting. It is common in the North and also elsewhere when seed is planted early. Much of the seed fails to germinate and rots because it is attacked by various seed-borne and soil-inhabiting fungi.

Root and stalk rots cause weakened plants, small poorly filled heads, and broken-over plants. Yields of forage and grain, as well as feeding value, are reduced.

Sorgo, called also sweet or sugar sorghum, is subject to the diseases that affect other sorghums, especially the leaf spots and anthracnose. It is also affected by red rot, especially in stalks stored for processing.

Sugar Beets

Sugar beet losses come from fungus, bacterial, and virus diseases. In beet-growing districts east of the Rocky Mountains leaf spot and black root, both fungus diseases, cause the heaviest losses. Leaf spot reduces both tonnage and quality by its destruction of the leaves. Black root, which is most serious in the districts where beets are grown under conditions of natural rainfall, causes poor stands. Both diseases result either in abandonment of acreage or in very low yields from such acres as are retained. Many of the plants that escape death as seedlings make only a stunted growth. In years with above-normal rainfall the crop, instead of benefiting by the moisture, suffers from leaf disease and poor stands.

Curly top, a virus disease transmitted by the beet leafhopper, is prevalent in the sugar-beet districts west of the Rocky Mountains. Although largely controlled by resistant varieties, this disease still lowers yields in many western States.

Minor diseases, including mildew, rust, and crown rot, also take a definite toll. The sugar-beet nematode and other nematodes limit production, particularly in the West and Midwest districts.

In all districts sugar beets in storage piles at factories are subject to losses from decay organisms that rot the roots. Factories are able to prevent much of this loss by installing air ducts through which cool night air is blown through the storage piles; but deterioration of the beets from storage rots in spite of ventilation is still a serious drain on the crop.

Sugar Cane

Sugar cane yields are still reduced by mosaic, but this destructive disease of the twenties is now largely controlled by use of resistant varieties. Recently ratoon stunting, caused by a virus, was recognized in the United States as associated with deterioration of sugarcane plantings in the second and third years of growth. The losses from this disease greatly augment the losses from Pythium root rot and red rot, two fungus diseases that bring about poor stands and cause deterioration of the stalks. These rots are serious in both Louisiana and Florida. Losses of sugar cane grown for sugar reduce the crop 13.5 percent; losses of sugar cane grown for sirup are lower because of less damage from red rot. On the other hand, mosaic does more

damage to sugar cane grown for sirup than to the highly resistant varieties used in sugar production. In Mississippi, Alabama, Georgia, and northern Florida, sugar cane grown for sirup is subject to the same diseases that affect the sugar cane grown for sugar. The significance of ratoon stunting disease with sugar cane grown for sirup has not yet been appraised.

Tobacco

At least five groups of parasitic diseases cause serious losses to the tobacco crop -- root rots, leaf spots, mosaic and other virus diseases, blue mold, and black shank.

The root rots reduce plant growth in every area. It is estimated that 50 percent control could be obtained if growers would use resistant varieties, proper rotations, and fumigation. Invasion of the leaves by the leaf spot parasites causes reduction in yield and affects the quality. At present not over 10 percent control is possible by use of fungicides. However, varieties immune from wildfire, one of the most important organisms of this group, are being developed. The virus diseases are prevalent in all areas, always retarding and reducing yields and quality of cured leaf. Probably 25 percent control would result from more general use of sanitary methods. Ultimate control appears to be through the use of resistant varieties which are being developed. Blue mold causes a shortage of transplants, delay in planting, and resultant poor stands. It commonly occurs in seedbeds each year and can be controlled by timely and thorough use of fungicides. The black shank disease appears to be on the increase, and control measures tend to become less effective. It kills the plants through root invasion and persists once the soil is infected. Some control is accomplished by use of rotation and resistant varieties.

A group of miscellaneous diseases occur in wide areas and occasionally cause some damage. Bacterial wilt and fusarium wilt are being controlled by use of resistant varieties. No effective control measures for sore shin and southern stem rot have been developed. Curing decays occur during August and September when humidity often becomes excessive while the tobacco is in the curing barns. Storage damage may take place when the packed tobacco contains excessive moisture. Temperature and moisture control offer an effective method to prevent these losses, but it is not always feasible to apply them.

Wheat

All the diseases of wheat reduce the yield, and some, such as stem rust, mildew, Septoria, mosaic, and the root and foot rots, also cause a shriveling of the grain with further loss in milling value. Spores of bunt or stinking smut are retained on the seed in threshing and, since they have an undesirable odor, such grain must be washed before milling. The rusts, Septoria, root and foot rots, and virus

diseases may also cause a reduction in leaf area during the fall and winter with consequent loss in value for pasture. Losses from the rusts, smuts, mosaic, and mildew have been materially reduced by the development of resistant varieties.

Leaf rust is the disease causing the largest average loss to the wheat crop for the country as a whole. It is present almost every year over most areas where wheat is grown except the drier sections of the West.

Losses from stem rust are most frequent in the spring wheat areas of the North Central States, particularly North Dakota, South Dakota, and Minnesota. Local losses may occur in other areas. Damage is not consistent from year to year, as it depends on the presence of favorable weather, susceptible varieties, and an abundance of inoculum. Most of the epidemics of recent years have resulted from inoculum that has lived over winter on wheat in Mexico and southern Texas. Prior to 1918 losses arose largely from inoculum that was disseminated each spring from rust infections on barberry leaves. Since then a vigorous barberry-eradication program has been conducted in the principal grain-growing States. Stem rust losses at one time averaged 50 million bushels annually, and during a single epidemic year amounted to as much as 200 million bushels. The average for the last 9 years has been about 15 million bushels.

Loss from bunt is heaviest in the Pacific Northwest and Intermountain States, although occasional losses occur in scattered fields in other wheat-growing areas. Losses in the Pacific Northwest vary from year to year, depending on the use of resistant varieties, of seed treatment, and on weather and soil-moisture conditions at seeding time. Loose smut causes significant losses only in the more humid sections, particularly the eastern part of the soft winter wheat area and the eastern parts of the hard red winter and hard red spring wheat areas. Losses are rather consistent from year to year.

Streak mosaic caused a loss of 7 percent of the Kansas wheat crop in 1949 and some loss in most years since 1949. Some losses, usually small, occur in nearby States. Soil-borne mosaic causes slight losses in Illinois, Indiana, North Carolina, and nearby areas almost every year.

Mildew and Septoria are present from Kansas and Texas eastward each year and may occasionally cause rather heavy losses in local areas. Scab sometimes causes losses when wheat follows corn if the cornstalks are not well covered or removed when the land is prepared.

Forage Crops

The loss estimates for forage crops have been restricted to those crops grown on land suitable for rotation farming. The losses in Table 2 are based principally on forage used for hay. Losses in pastures and ranges attributable to diseases are reported in Chapter VI under the heading "Pastures and Ranges."

Alfalfa

Bacterial wilt, and in some cases the fungus diseases of alfalfa, have been most destructive through early stand losses, which have reduced the productive life of fields in the humid and irrigated areas of the country from 6 or more to only 2 or 3 years. Since unproductive fields are generally plowed and planted to other crops, the loss caused by bacterial wilt is not truly reflected by the loss in yield and quality of the short-lived crop. Wilt-resistant varieties have been made available in sufficient quantities to overcome about a third of this loss. Ranger and Buffalo have filled the need for adapted wilt-resistant varieties in most areas. Where winter hardiness coupled with wilt resistance is required, the new variety Vernal soon will be available. The fungus diseases attacking the leaves and stems of alfalfa also limit the productive life of the stand, but are more important in reducing the annual harvest in both amount and quality. The development of disease-resistant varieties offers promise in bringing these pests under control.

The stem nematode of alfalfa was first recognized as an important pest in some of the valleys of California and western Nevada. It is spread rapidly across fields by irrigation water. Where the pest exists the loss is heavy. Damage may be noted at any time during the growing season, but appears to be most severe in the spring and early summer. Infected plants are dwarfed and have fewer stems. Susceptible varieties are completely eliminated in 2 to 3 years. The pest is now controlled most effectively by the growing of resistant varieties. The damage may be reduced, but is likely to continue because the nematode is spreading into areas where adapted resistant varieties are not yet available.

The virus that causes Pierce's disease of grape also affects alfalfa, in which the resultant disease is called alfalfa dwarf. It is confined principally to the southern two-thirds of California and the western third of Arizona. The incidence of dwarf disease depends upon the proximity of alfalfa fields to fields of diseased grapes and upon the population of insect vectors. Alfalfa plants infected by the virus become dark green and dwarfed. They gradually decline in vigor and eventually die prematurely.

Clovers

More than a dozen diseases attack the true clovers and sweetclover, causing severe losses of stand, yield, and often final destruction of the crop. Leaf and stem diseases also reduce the quality of the hay or pasture produced. The estimated losses do not take into account the reduced value in pastures or grazed hay fields from which no hay or seed is removed. Since white clover and crimson clover are used primarily for pasture and the total feed production from all pasture and range land is about twice that harvested as hay, it is reasonable to assume that disease loss of the clovers in pastures alone may well exceed the losses from all diseases causing injury to all hay crops.

Table 2. Losses Due to Diseases of Forage Crops

Commodity and unit of production	Actual production 1/ Quantity	Actual production 1/ Harvested Acreage	Actual production 1/ Value	Loss of production 2/ Percentage	Loss of production 2/ Quantity	Loss of production 2/ Value	Loss of production 2/ Acreage equivalent due to loss
	1,000 units	1,000 acres	1,000 dollars	Percent	1,000 units	1,000 dollars	1,000 acres
Soybeans (for beans) (bu.)	219,596	11,114	511,620	12.5	31,370	73,088	1,389
HAY							
Alfalfa (fungus and bacterial diseases) (tons)	35,252	15,925	721,961	27.0	13,038	267,027	4,300
Alfalfa (due to nematodes) (tons)	(7,315)3/4/	(2,199)3/	(163,231)3/	3.0	226	5,048	66
Alfalfa (due to viruses) (tons)	(3,072)3/	(758)3/	(72,394)	6.0	196	4,621	45
Clover (tons)	15,512 5/	11,0445/	291,114	50.0	15,512	291,114	5,522
Lespedeza (tons)	7,110	6,629	145,040	18.0	1,561	31,838	1,193
Sweet clover and tame grasses (other) (tons)	9,093	7,991	185,606	9.6	966	19,792	770
Timothy (tons)	15,5125/	11,0445/	291,1145/	9.06/	1,534	61,7516/	1,9336/
Wild hay (tons)	12,627	14,380	151,486	5.0	665	7,973	719
Sub-totals for Hay (tons)	95,106	67,013	1,786,321		33,698	689,164	14,548
SEED							
Alfalfa (due to nematodes) (lbs.)	27,078	(144)	8,4307/	3.08/	837	261	(4)
Alfalfa (due to viruses) (lbs.)	(9,040)	(40)	(2,573)	6.08/	577	164	(2)

Alsike clover (lbs.)	14,400	115	4,252	3.0	445	132	3
Birdsfoot trefoil (lbs.)	316	5	396	17.5	67	84	1
Crimson clover (lbs.)	17,167	(91)	3,411	12.0	2,341	465	(11)
Grass seed (lbs.)	165,891	(705)	16,019	20.0	41,473	4,005	(141)
Lespedeza (lbs.)	172,304	883	14,911	18.0	37,823	3,273	(159)
Lupine (lbs.)	50,978	63	2,333	7.5	4,133	189	5
Red clover (lbs.)	92,967	(1,836)	31,663	50.0	92,967	31,663	(918)
Sweet clover (lbs.)	42,140	(285)	4,690	5.0	2,218	247	(14)
Vetch, Hairy (lbs.)	27,336	135	3,852	10.0	3,037	428	13
Sub-totals for Seed(lbs.)	610,577	318 9/	89,957	-	185,918	40,911	22 9/
TOTAL FOR FORAGE CROPS	-	78,445	2,387,898	-	-	803,163 10/	15,959

1/ See footnote 1 of Table 1. Production and acreage data are from July 1953 Crop Production report and cover the period 1942-51. Values shown are from special data supplied to the committee by Agricultural Estimates Division, AMS.
2/ See footnote 2 of Table 1.
3/ Only that part of the U. S. crop which is in infested area.
4/ Figures in parentheses are included in figures elsewhere in table, and accordingly are not added into totals.
5/ Census and Department of Agriculture estimates combine clover with timothy; while clover is believed to constitute considerably more than half the total of these two hay crops and suffers more disease loss than timothy; nevertheless the computations in this table are made on the basis of clover and timothy each comprising half the production, value, and acreage. The losses shown are thus believed to be below the actual totals.
6/ Loss in value from diseases of timothy was estimated at 17.5%.
7/ Represents the total U. S. crop although only part is in infested area.
8/ Percentage applies only to infested area.
9/ These acreage equivalent and crop acreage totals represent only those parts of the seed-producing acreage that are not included in the hay figures above.
10/ See also range disease losses in Table ?.

Lespedeza

Bacterial wilt, southern blight, and root-knot nematodes damage the lespedeza crop in most areas where it is grown. The root-knot nematode has become so destructive in the sandy soils of the Coastal Plain that susceptible varieties can no longer be grown successfully in that region. Fortunately nematode-resistant strains have been developed, and one is now being grown. Use of resistant varieties in the future may be expected to reduce loss from nematodes by 5 or 6 million dollars. Southern blight kills the plants soon after they are attacked, and the loss varies considerably from year to year. Crop rotations that limit the regular establishment of lespedeza are helpful in controlling blight. The development of disease-resistant varieties appears to be the best remedy for bacterial wilt.

Soybeans

About half of the 25 diseases attacking soybeans in the United States are of economic importance. The annual reduction in soybean yields caused by diseases has averaged 12.5 percent during the last 10 years, amounting to 73 million dollars. The bacterial diseases, blight, pustule, and wildfire, are most widespread. They cause severe defoliation and substantial reductions in yield. Prior to 1948 the bacterial diseases were important only in the South, but now they are destructive to soybeans in the Midwest as well. Varieties resistant to pustule and wildfire will soon be in production in the South, but no resistant varieties are available for the Midwest.

The two most important fungus diseases, stem canker and brown stem rot, infect the stems and may cause the plants to die before seeds are matured, or greatly reduce the quantity of seed produced when the plants are not killed. They occur in the heavy producing areas of the Midwest, where it is not uncommon to find fields in which half the plants have been killed. Such infection greatly reduces yields and demonstrates how destructive these two diseases may become. More than a thousand selections have been tested for resistance to these diseases, but no resistant ones have been found.

Other important fungus diseases include downy mildew, which occurs each year in all soybean-producing areas of the United States; brown spot, which has been particularly severe in Indiana and Ohio; frogeye, which may be found in all producing areas some years and has been particularly severe in Indiana; rhizoctonia root rot, which occurs primarily in the northern portion of the soybean-producing area and has caused heavy damage in the heavy producing State of Minnesota. Targetspot, which has been found only in the Southern States, was observed first in 1945 and has been destructive in Louisiana and Mississippi in some years since that date.

Virus diseases have caused little damage to soybeans in general, but have occasionally caused serious losses in localized areas along the Mississippi River in Iowa, Illinois, and Missouri.

Table 3. Losses Due to Diseases of Fruit and Nut Crops

Commodity and unit of production		Actual production 1/			Loss of production 2/			
		Quantity	Acreage	Value	Percentage	Quantity	Value	Acreage equivalent due to loss
		1,000 units	1,000 acres	1,000 dollars	Percent	1,000 units	1,000 dollars	1,000 acres
Almonds	(tons)	35	105	18,324	1.5	1	279	2
Apples	(bu.)	128,000	1,500	230,000	6.0 3/	8,170	47,108 3/	255
Apricots	(tons)	226	73	21,589	1.5	3	329	1
Blueberries	(qts.)	16,050	31	4,538	10.0	1,783	504	3
Citrus fruits	(boxes)	170,647	827	322,763	3.0	5,278	9,982	25
Cranberries	(tons)	39	26	12,434	22.0	11	3,507	6
Cherries, sour	(tons)	107	85	18,659	22.0	30	5,263	19
Grapes	(tons)	2,874	616	159,107	4.0	120	6,629	25
Hazelnuts(filberts)	(tons)	7	24	2,510	2.5	4/	64	6
Peaches (diseases other than mosaic and phony-peach)	(bu.)	67,012	662	120,585	4.5	3,158	5,682	30
Peaches (due to phony-peach)	(bu.)		-		3.3 5/		891	2
Peaches (due to mosaic)	(bu.)		-		0.9 5/		603	1
Pears	(bu.)	30,396	176	62,398	5.5	1,769	3,632	10
Pecans	(lbs.)	126,518	202	27,139	6.0 6/	8,053	3,877 6/	25
Strawberries (commercial)	(crates)	8,695	118	60,340	6.2	576	4,000	7
Tung nuts	(tons)	43	250	3,525	1.5	1	54	4
Walnuts	(tons)	70	150	29,867	5.0 7/	4	1,906 7/	9
TOTAL FOR FRUITS		-	4,845	1,093,778	-	-	94,310	430

1/ See footnote 1 of Table 1.

2/ See footnote 2 of Table 1.

3/ Loss in value from diseases of apples was estimated at 17.0%.

4/ Amount less than 500 tons.

5/ Percentage applies only to infested area.

6/ Loss in value from diseases of pecans was estimated at 12.5%.

7/ Loss in value from diseases of walnuts was estimated at 6.0%.

Tame Hay

Foliage diseases similar to those attacking timothy (see below) inflict heavy losses in tame grasses. More information is needed on both the acreage of these grasses and the diseases attacking them before complete and reliable figures on losses can be obtained. In some areas leaf blight has caused severe damage to Sudan grass. Losses of 35 to 50 percent have been measured. Similarly, the yield of orchardgrass has been reduced 5 to 7 percent by Stagonospora leafspot. Kentucky bluegrass pastures sampled in several parts of the Northeast were found to contain up to 30 percent of the plants infected with stripe smut. This is probably part of the explanation for their low productivity during hot, dry months of midsummer, when infected plants die.

Timothy

Four important foliage diseases, namely, Heterosporium leaf blight, crown rust, anthracnose, and brown stripe, attack timothy, causing some reduction in yields but a greater loss in hay quality. The degree of infection varies tremendously, depending on the prevalence of the organism and seasonal conditions. For example, rust or Heterosporium leaf blight may cause severe damage in certain areas in some years.

Vetch, Lupine, and Birdsfoot Trefoil

The seed loss due to diseases in plantings of these crops grown for seed production, valued at nearly $700,000, is actually less than the loss of seed due to unsatisfactory harvesting methods or poor equipment. Diseases cause more loss to fields used for grazing, hay, or soil improvement than to the seed crop.

Wild Hay

Diseases attacking the plants from which wild hay is made include rusts, smuts, leaf spots, and root rots in varying amounts depending upon the components of the mixture, on the season, and other environmental factors.

Fruit and Nut Crops

Estimates of losses in fruit and nut crops have been restricted to those grown commercially. Limited acreages for home and farm plantings and on small estates have not been considered.

Losses attributable to nutritional disturbances are included only in the case of pecans, where deficiencies in minor elements are corrected by including them in pesticide sprays.

The losses caused by diseases to fruit and nut crops are summarized in Table 3.

Almonds

Owing to climatic requirements the almond is grown on a commercial scale only west of the Rocky Mountains. Plantings are particularly extensive in California.

Two fungus diseases are prevalent in all almond-growing areas. Brown rot is a serious disease of the blossoms. The fungus can materially reduce the size of the crop through the blighting of the blossoms. The other disease, called coryneum blight or shot hole, causes extensive gum production and killing of the blossoms, twigs, and branches. Both diseases are controlled by the use of copper sprays just before the blossoms open but after they have emerged from the winter buds. Occasionally in rainy springs a second application is required at the end of the blooming period.

Apples

Apple scab, a fungus disease, is perhaps the most important problem facing apple growers east of the Rocky Mountains. The fungus is widely distributed and is a threat every year. The fruit is rendered worthless in severe cases, and even scattered infections result in misshapen, small fruit. The leaves likewise are invaded. The disease can be controlled by properly timed applications of sulfur or an organic fungicide. Apple blotch, black rot, cedar apple rust, bitter rot, sooty blotch, and fly speck also take a toll of the fruit in the East. These fungus diseases are more sporadic in occurrence than scab, but in favorable years can destroy appreciable quantities of the crop. Blotch and bitter rot cause more damage in the southern part of the Apple Belt. Most of these fungus diseases are of little importance in the more arid fruit-growing sections of the Far West. Apple mildew is extremely prevalent, however, in the West and is very difficult to control, especially on the Jonathan variety. Occasionally apple scab causes marked losses in western orchards, especially in seasons of heavy rainfall.

Apricot

The apricot, like the almond, is grown on a commercial basis only in the Far West. Most of the commercial acreage is in California, but large plantings exist also in Washington and Utah.

Brown rot and shot hole (Coryneum) are universally present in these western apricot orchards. These fungus diseases are responsible for gum flow, blighting of the twigs and blossoms, and Coryneum also spots the leaves and fruit. These two diseases do most damage during the blossom period. They represent a constant threat to the industry, but can be held under control by the use of copper sprays in the dormant period.

Blueberry

Commercial blueberry culture is confined largely to special areas in Massachusetts, Michigan, New Jersey, and North Carolina. Blueberry plantings are affected by various diseases, but mummy berry, due to a fungus, and stunt, a virus disease, are the two major commercial problems.

Mummy berry occurs in all the blueberry-growing areas. The young blossoms are infected, and the fruit is converted into a hard, inedible mass as the result of the development of the fungus in the inner tissues. Blighting of the twigs further reduces the size of the crop. Partial (about 75 percent) control is achieved by using caustic sprays to kill the fungus on the ground and by spraying the bushes with fungicides to protect them from infection. Stunt occurs only in New Jersey and North Carolina. Infected plants slowly decline in vigor, become unproductive, and eventually die. Control measures include use of disease-free nursery stock, roguing of diseased fields, and vector control by use of insecticides.

Cherries, Sour

The commercial production of sour cherries is seriously affected by two types of disease. The fungus disease leaf spot (Coccomyces) occurs in plantings east of the Rocky Mountains. It causes spots and a shot-hole effect on the leaves and excessive defoliation. It is present every year and requires a regular spray program of sulfur, copper, or organic material for its control. Sour cherry yellows, a virus disease, occurs wherever sour cherries are grown in the United States. The disease is manifest by a yellow-green mottling of the leaves followed by successive periods of defoliation. The trees are not killed, but the number of fruit-bearing spurs is reduced each year. The only control is the production and use of certified disease-free nursery stock.

Citrus

Citrus trees and fruit are affected by a number of fungus diseases, which for the most part are kept under control without much effort. On the other hand, several virus diseases, especially tristeza and quick decline, which are very like each other and may be caused by the same virus or by strains of one virus, menace the very existence of the citrus industry. The virus diseases occur in Florida, along the Gulf coast, and in California, and it is estimated that 1,500,000 trees are killed every year. The trees gradually lose vigor and become less productive for several years prior to their death. The sour orange, long used for citrus rootstocks, is extremely susceptible to the causal virus or viruses, and control depends on the finding and use of satisfactory resistant rootstocks.

Cranberry

Cranberries are affected by a number of fungi that destroy the fruit both in the field and after harvest. Apparently some of these fungi infect the fruit early in its development. Fruit rots that do not appear until August can be controlled by spraying the vines in the blossom period. Spray treatments are only about 50 percent effective, however, and fruit rots are an important problem in all the cranberry-growing areas. Another important problem in Massachusetts, Wisconsin, and New Jersey is false blossom, a virus disease, which eventually makes the plants nonproductive. Control is difficult. Insecticide sprays to eliminate the insect vector and the planting of klendusic varieties (varieties that do not become infected because for some reason they are not attractive to the insect) are standard procedures at the present time.

Grapes

Climatic factors are so important in commercial grape production that the high-quality European table grapes can only be grown in the Western States.

In the East the American bunch grapes are affected primarily with black rot and downy mildew. The black rot fungus infects all the green parts of the plant and causes a severe rotting of the fruit. Black rot is much more difficult to control in the southern part of the country. Downy mildew, on the other hand, is mainly a leaf disease that affects the metabolism of the vines. These diseases are a constant threat to the industry and require the use of copper compounds and dithiocarbamates in sprays.

In the West the vinifera or European grapes are attacked mainly by the powdery mildew fungus, which spots the leaves and fruit. Affected fruit is apt to crack and mold in transit. Powdery mildew is readily controlled by sulfur sprays. The vinifera varieties are very susceptible to the black rot fungus, but fortunately western climates are too dry for the disease to develop. Pierce's disease is important and widespread in California where it has greatly reduced production in many vineyards. In some parts of the State it has caused or hastened the replacement of grapes by some other crop. The causal virus attacks numerous other plants, including alfalfa (alfalfa dwarf) and many grasses. It is carried by an insect vector from one host to another. Diseased alfalfa fields are a source of infection for nearby vineyards, and vice versa.

Hazelnuts (Filberts)

Hazelnuts are grown commercially in Oregon and Washington. Bacterial blight is present in all the plantings. The organism attacks the buds, leaves, branches, and trunk of the trees. The nuts are rarely attacked directly, but the size of the crop is reduced by the killing of the fruiting twigs. Copper sprays applied in the fall and early spring are effective control procedures.

Peach

In the East bacterial spot is probably the most serious disease with which the peach grower has to contend. No really satisfactory control measure is known, and the continued defoliation year after year weakens the trees and predisposes them to winter injury.

Brown rot, scab, and peach leaf curl are three fungus diseases widely distributed in the United States. In certain seasons they can cause extensive crop losses, particularly in the humid East, and sometimes even western orchards suffer from brown rot and leaf curl. Control measures that are effective in all but extremely rainy seasons have been developed and are widely used by commercial growers.

Coryneum blight is a destructive disease confined to western fruit orchards. It causes shot-hole of the leaves and twig blighting and spotting of the fruit. Like the leaf curl fungus, the organism is a constant threat, and growers regularly apply a dormant spray which gives effective control.

Phony disease was first observed in central Georgia in 1890. It occurs in the Southeastern United States and in scattered areas as far west as Oklahoma and north to Illinois and Pennsylvania. The affected trees develop shortened internodes, numerous lateral branches, and flattened dark-green leaves. The fruit becomes progressively smaller and inferior in quality. In addition to peach the disease attacks nectarine, apricot, almond, and wild and cultivated plum. The virus that cuases it is spread by insects. Affected trees are not killed, but their productive capacity and consequently their commercial usefulness is impaired by the second year after infection can be diagnosed.

Phony peach is particularly destructive in Georgia, where it is not uncommon for an orchard to be 99 percent infected by the time it is 12 years old. The only control measure known is removal of affected trees, and in a definite eradication program begun in 1929 about 1,600,000 trees have been removed and destroyed. Losses in 1952, based on trees removed from 1949 to 1951 on account of the disease, were estimated to be in excess of $1.5 million. These losses include, besides direct loss of crop, losses to the transportation, container, and insecticide industries and losses affecting sales of nursery stock. Should the disease be introduced into California, it would threaten an $80 million industry. Insect species closely related to the vectors of phony disease are known to occur in California.

Peach mosaic, another virus disease of peach and certain horticultural varieties of plum, is general in the Rio Grande Valley,

southern California, Utah, Arizona, New Mexico, and other parts of Texas and Mexico. It has been reported from southern Oklahoma, western Arkansas, and western Colorado. The virus is present in many forms, some of which are very mild in their effect and others very destructive, particularly on the J. H. Hale, Elberta, and Rio Oso Gem varieties. In some areas fruit production is markedly reduced both in quality and quantity.

Control of peach mosaic is difficult owing to its extensive range plus the presence of some mild forms that make detection difficult. Removal of affected trees coordinated with a nursery-inspection program and quarantine procedure is preventing further spread of the disease. Where no effort is made to control the disease, infected orchards become unprofitable within a few years. Thus far about 400,000 peach trees have been destroyed by the infection. Direct losses during 1952, on the basis of trees removed because of the disease between 1950 and 1952, were estimated to be about $93,000. The value of the 1952 peach crop in the infected areas of States where control programs were conducted was estimated to be in excess of $10 million, not including the nursery products regulated under State quarantines, which were estimated to be worth around $700,000.

Pears

The destructive effect of pear blight has restricted the commercial production of high-quality pears almost exclusively to the Pacific Coast States. Under the more arid climate in these States pear growing can be profitable even though none of the orchards are entirely free from the threat of pear blight.

However, pear scab and stony pit are important problems facing commercial growers in the Far West. Pear scab is present every year and causes spots on the leaf, fruit, and twigs. The fruit is distorted and rendered unmerchantable, and sometimes the trees are partially defoliated. Organic fungicides will control the organism, but they must be applied at proper intervals. Stony pit, a virus disease, causes hard pits to form on the fruit. Badly distorted fruit is worthless. Severity of the disease fluctuates from year to year. No control measure is known, but fortunately the Bartlett pear, although a symptomless carrier, shows no bad effects from infection.

Pecans

The commercial pecan industry is located in the Southern States from South Carolina through Georgia, Florida, and westward to Texas and Oklahoma. Scab is present throughout this region and

is probably the most serious disease affecting the crop. It is especially damaging on susceptible varieties, but fortunately only about one-tenth of the acreage is planted to these varieties. Leaf spots due to various fungi, crown gall, and nutritional troubles all help to reduce the size of the crop. These diseases occur every year and require numerous applications of bordeaux mixture or zinc dithiocarbamate.

Strawberries

Strawberry plants are affected by various leaf spot fungi, and some fungi have been isolated from the mature fruit. These leaf and fruit organisms are responsible for appreciable losses in certain seasons. However, plant pathologists consider the losses from these fungus diseases to be minor in comparison with those from virus diseases, such as yellows, crinkle, leaf roll, and witches'-broom. These diseases are widespread, and some plantings show from 80 to 100 percent of the plants affected. The plants are stunted and made unproductive, and the size and quality of the fruit are materially reduced. The only control is to develop stocks of virus-free plants and prevent their subsequent infection by the control of insect vectors.

Tung Trees

Tung trees are cultivated on a commercial basis in a narrow belt approximately 100 miles wide along the Gulf of Mexico from eastern Texas to Florida. In general, this crop has been free of fungus diseases, but occasional plantings are affected by the thread-blight fungus. The fungus kills leaves and twigs, and the yield of nuts is accordingly reduced. Fortunately the disease is readily controlled with one application of bordeaux mixture. Occasionally the trees are attacked by a bacterial organism causing a definite leaf spot, but the loss generally is minor. The main problems in the growing of tung trees are nutritional conditions, most of which can be corrected by proper fertilizer applications.

Walnuts

Blight due to a bacterial organism is destructive in the extensive commercial plantings of walnuts in California and Oregon. The disease primarily affects the nuts, but it may also spot the leaves and blight the blossom clusters early in the spring. Bordeaux mixture or copper-lime dusts will control the disease, and generally at least four applications are necessary each season.

Vegetable Crops

The estimates of disease losses in vegetable crops, as given in Table 4, include only the important commercial crops on which reasonably accurate data are available. Serious losses are known

Table 4. Losses Due to Diseases of Vegetable Crops

Commodity and unit of production		Actual production 1/ Quantity	Actual production 1/ Acreage	Actual production 1/ Value	Loss of production 2/ Percentage	Loss of production 2/ Quantity	Loss of production 2/ Value	Acreage equivalent due to loss
		1,000 units	1,000 acres	1,000 dollars	Percent	1,000 units	1,000 dollars	1,000 acres
Artichokes	(boxes)	726	7	2,268	5.0	38	119	3/
Asparagus	(tons)	158	126	29,610	9.0	16	2,928	11
Beans, green snap	(tons)	515	311	65,585	22.0	145	18,498	68
Beans, green lima (shelled)	(tons)	67	102	11,402	8.0	6	991	8
Beets, table	(tons)	196	28	4,727	3.0	6	146	1
Cabbage	(tons)	1,290	153	54,826	8.0	112	4,767	12
Cantaloupe (1951)	(tons)	487	123	43,089	17.0	100	8,825	21
Carrots	(tons)	734	74	52,634	8.0	64	4,577	6
Cauliflower	(crates)	11,617	33	15,045	10.0	1,290	1,672	3
Celery (1951)	(tons)	709	37	53,470	16.0	135	10,185	6
Corn, sweet	(tons)	1,736	681	59,237	5.5 4/	101	4,118	44
Cucumbers, greenhouse		-	-	1,277	8.0	-	111	-
Cucumbers, pickling	(tons)	212	113	10,929	13.5	33	1,706	15
Cucumbers, fresh market	(bu.)	5,606	46	12,096	19.5	1,358	2,930	9
Sub-totals for field cucumbers		-	159	23,025	-	-	4,636	24
Eggplant	(bu.)	1,380	6	1,979	14.0	225	322	1
Escarole (1951)	(tons)	30	5	2,419	5.0	2	127	3/
Kale (1951)	(tons)	10	3	904	7.5	1	73	3/

Lettuce field (1951) (tons)	1,268	205	122,456	12.0	173	16,698	24
Melon, Honeydew (crates)	3,293	12	5,982	15.0	581	1,056	2
Melon, Honeyball (1951) (tons)	1	3/	144	13.0	3/	22	3/
Onions (sacks)	40,132	135	51,399	22.0	11,319	14,497	30
Peas, green (shelled) (tons)	446	480	43,198	23.0	133	12,903	110
Peppers, green (1951) (tons)	112	37	18,755	14.0	18	3,053	5
Potatoes (bu.)	411,007	2,318 5/	551,789	20.1	103,393	138,808	466
Shallots (1951) (tons)	7	5	1,067	21.0	2	284	1
Spinach (tons)	220	84	16,687	27.0	81	6,172	23
Sweet potatoes (bu.)	54,331	591 5/	108,213	17.0	11,128	22,164	100
Tomatoes for processing (tons)	2,836	471	71,991	27.0	1,049	26,627	127
Tomatoes for fresh market (1951) (tons)	914	228	119,676	26.0	321	42,048	59
Tomatoes, greenhouse	-	-	10,077	24.0	-	3,182	-
Tomatoes (plant beds)			1,500	10.0		150	
Watermelons (melons)	86,143	330	28,318	13.0	18,872	4,231	43
TOTAL FOR VEGETABLES	-	6,744	1,572,749	-	-	353,990	1,195

1/ See footnote 1 of table 1.

2/ See footnote 2 of table 1.

3/ Acreage equivalent is less than 500.

4/ Loss in value from diseases of sweetcorn was estimated at 6.5%.

5/ Planted acreage.

to occur in scores of minor vegetable crops as well. No attempt has been made to estimate losses in home gardens and other non-commercial plantings.

Artichokes

Globe artichokes are not subject to many serious diseases. Most of the losses are due to gray mold, a decay of older bud scales and growing buds which may also involve the stem and lateral branches. It also damages artichokes in transit. The causal fungus persists in the soil, and moist weather is essential to infection. No control measures have been developed other than crop rotation. Recently there has been some loss from curly dwarf, a virus disease that causes a stunting and premature death of the plants. No control has been developed for this disease. Losses occur chiefly in California, where most of the crop is grown.

Asparagus

Nearly all losses from disease in asparagus are caused by rust. This fungus affects the stems that develop after the cutting season is over and causes the needle-like branches to fall. This injury to the top growth reduces the storage of reserves in the fleshy roots, and consequently the vigor and yield of the plants the next year. The marketable portions of the plant, however, are not infected. Rust occurs throughout the United States, but is most severe in humid regions. It is partially controlled by the use of moderately resistant varieties.

Wilting of the stalks and decay of the roots also cause some losses of asparagus. No control has been developed.

Beans, Fresh Lima

Losses from disease are caused chiefly by seed decay, root rots, downy mildew, and the root-knot nematode. Root rot and seed decay are most damaging in the South, but occur wherever the crop is grown. Downy mildew causes some damage along the Atlantic Seaboard and occasionally in other sections. The common bacterial blight and halo blight of snap beans also affect lima beans, although much less seriously, and there is a bacterial pod spot. Root-knot nematodes cause appreciable loss in the Southern States. Virus diseases are negligible.

Seed decay can be greatly reduced by chemical seed treatment, and rotation helps to reduce losses from root rot. Fungicides will check downy mildew. The use of western-grown seed will reduce injury from bacterial blight. Rotation is also the chief means of controlling the root-knot nematode because of the high cost of soil fumigants.

Beans, Fresh Snap

Losses in snap beans are caused by parasitic fungi, bacteria, viruses, root-knot nematodes, and mechanical injury to the seed. Root rot and seed decay, caused by fungi, are a major cause of loss wherever the crop is grown, particularly in the South. Other chief causes of loss are bacterial halo blight, rust, and watery soft rot. The common bean mosaic virus and bean yellow mosaic virus cause serious losses from stunting of the plants. Bald head of seedling beans, caused by injury to the seed in threshing, reduces stands in many fields.

Halo blight is most damaging in humid sections. Rust is most common in coastal sections of the South and in southern California, Oregon, and Washington; its spread is favored by moist weather and cool nights. Watery soft rot causes losses in the Gulf States and in western Oregon. The curly top virus causes little loss where snap beans are grown for market or canning, but prevents their production in eastern Idaho, Washington, and Oregon. Root-knot nematode losses are most important in the warmer regions of the United States.

Losses from seed decay and root rots can be reduced by chemical seed treatment and rotation, and from bacterial blight by using clean seed grown in the semiarid West. Rust can be controlled by sulfur dusts. Crop rotation helps to prevent serious loss from watery soft rot. A number of bean varieties are resistant to common bean mosaic, but we have none resistant to bean yellow mosaic or to curly top. Rotation aids greatly in preventing serious loss from root-knot nematodes.

Beets, Table

Table beets are not generally injured greatly by disease. Most of the loss is caused by seedling diseases, downy mildew, leaf spots, root-knot nematodes, and boron deficiency. Black root causes damping-off of seedlings; it occurs wherever beets are grown. Downy mildew affects all the above-ground parts of the plant, particularly the leaves. It is confined almost entirely to the Pacific coast. Cercospora leaf spot is common east of the Continental Divide, but does not cause severe loss. Root-knot nematodes are most damaging to beets in the Western States. Boron deficiency is probably the most serious disease of beets grown for canning in the Northern States; it is characterized by the death of young leaves and the presence of blackened tissue in the roots.

Control measures consist chiefly of chemical seed treatment to reduce loss from black root and application of boron to the soil. Fungicides are not generally used to control leaf diseases.

Cabbage

The diseases responsible for most of the cabbage losses are clubroot, black rot, blackleg, Fusarium yellows, downy mildew, root knot, and mosaic. No one disease causes severe loss of the crop.

Clubroot, which is widespread in the Northern United States, causes enlarged clublike swellings on the root and dwarfs the plant. Black rot, which occurs chiefly in humid regions, causes large dead spots on the leaves, followed by leaf drop and decay of the heads. Blackleg is a widespread disease that causes stem cankers of seedlings near the soil line and spotting of the leaves. Yellows causes a wilting and drop of older leaves and stunting of the plants; it may occur wherever cabbage is grown. Downy mildew, which is most prevalent in coastal regions, affects the leaves but is chiefly a seedbed disease. Mosaic causes mottling and some necrotic spotting of the leaves; it may occur throughout the United States.

Losses from clubroot can be avoided by rotation and use of clean seedbed soils. Western-grown seed is usually free from the organisms causing black rot and blackleg. Hot-water treatment will disinfect contaminated seed. Losses from yellows are avoidable by the use of resistant varieties. Fungicides will control downy mildew in seedbeds and in the field. Mosaic losses can be reduced by isolation of seedbeds from plants that may serve as sources of the causal virus.

Cantaloups

The losses to cantaloups are caused chiefly by leaf blights, root-knot nematodes, and virus diseases. The most important leaf diseases are downy mildew, powdery mildew, and anthracnose. Alternaria leaf spot also causes some loss. The squash mosaic virus, strains of cucumber mosaic virus, and the curly top virus cause serious damage in the West. Minor losses are caused by bacterial wilt.

Losses from many of the diseases affecting cantaloups are regional. Downy mildew as a major disease is confined largely to the Atlantic Seaboard and the Gulf States. Anthracnose, alternaria leaf spot, and bacterial wilt are important only in humid areas east of the Continental Divide. On the other hand, powdery mildew is most destructive in California and Arizona. Mosaic viruses are much more damaging in California and Arizona than in the Central and Eastern States. Curly top is confined to areas in California and other Western States where the insect vector, the beet leaf hopper, occurs. The root-knot nematode causes some damage wherever cantaloups are grown.

The leaf diseases other than powdery mildew are fairly well controlled by fungicides. Resistant varieties have greatly reduced

losses from powdery mildew. So far no satisfactory control measure for virus diseases has been developed.

Carrots

The diseases responsible for most of the losses in carrots are bacterial leaf spot, which causes a leaf spot and dark spots on the roots, cercospora blight and alternaria blight, which damage the foliage, black rot of the roots, injury by the root-knot nematode, and yellowing and distortion of the leaves due to the aster yellows virus.

Bacterial leaf spot occurs chiefly in California and the other Southwestern States. The other carrot diseases are present wherever the crop is grown. The fungus leaf spots, however, cause serious damage only where there is a humid climate during the growing season.

Losses from leaf spot can be reduced by the use of fungicides, seed treatment, and crop rotation. Rotation is also the means generally employed to control the root-knot nematode. Losses from aster yellows can be reduced by dusting with insecticides to control the leafhoppers that transmit the virus.

Cauliflower

The diseases causing most of the losses in cauliflower are the same as those that affect cabbage. They are of about the same importance on both crops, except yellows to which cauliflower is resistant. Control measures are the same.

Celery

Celery is subject to losses caused by leaf blights, Fusarium yellows, stalk rots, root-knot nematodes, virus infections, and nonparasitic disorders.

The major leaf diseases are early blight and late blight, and some loss is caused by bacterial leaf blight. The root-knot nematode and the stubby root nematode are responsible for serious losses in Florida and root-knot injury occurs in other sections. The cucumber mosaic and the western aster yellows virus cause appreciable loss. The important nonparasitic diseases are blackheart, caused by sudden saturation of the soil with water, and cracked stem, which is due to boron deficiency in the soil.

Most of the major diseases of celery occur wherever the crop is grown, although pink rot is most common in Florida. Western aster yellows is limited to western States and is damaging chiefly in California.

Losses from leaf blights can be reduced by the application of fungicides and by hot-water treatment of the seed. A variety re-

sistant to early and late blight has been introduced and Fusarium yellows-resistant varieties are available. In Florida flooding of celery soils and heavy applications of cyanamide have helped to reduce loss from pink rot, but the disease is hard to control. Destruction of perennial weed hosts near celery fields helps to reduce damage by mosaic viruses. Western aster yellows has not been controlled satisfactorily.

Corn, Sweet

The sweet corn crop may be damaged by seedling blights; ear, stalk, and root rots; smut; leaf blight; and bacterial wilt. The stubby root nematode also causes some injury.

Seedling blights occur in all corn-growing areas, but their severity depends on the climate. Stalk, ear, and root-rots cause variable losses in both northern and southern areas. Smut and leaf blight are present in all corn-growing areas; the latter has been particularly severe in Florida. Bacterial wilt occurs throughout the Corn Belt and in the Eastern and Southern States. Nematode injury is more common in the South.

Seed decay can be reduced by chemical seed treatment. In recent years there has been some spraying for control of leaf blight in Florida. Resistant varieties have reduced losses from bacterial wilt. Good cultural practices help to control stalk and ear rots and smut.

Cucumbers, Greenhouse

The principal causes of losses of cucumbers in the greenhouse are powdery mildew, cucumber mosaic, and root knot. There are minor losses occasionally from bacterial wilt and from stem rot. All these diseases may occur wherever the crop is grown.

Powdery mildew can be controlled by proper temperature and ventilation and by sulfur dusts. Fumigation to destroy aphid vectors helps to avoid serious loss from cucumber mosaic and bacterial wilt. Steam sterilization of the soil will generally prevent damage from root-knot nematodes and from stem rot.

Cucumbers for Fresh Market

The losses of cucumbers grown for fresh market are caused chiefly by downy mildew, anthracnose leaf blight and fruit rot, angular leaf spot, cucumber mosaic virus, and root-knot nematodes. Minor losses are caused by scab and bacterial wilt.

Loss from downy mildew is probably greatest, although it is confined to the Atlantic coast. Anthracnose and angular leaf spot are widespread in humid regions east of the Continental Divide, and

mosaic is a major cause of loss in many cucumber-growing areas. Scab is troublesome chiefly in the northern tier of States from Minnesota to Maine, but occurs on fall cucumbers in North Carolina and causes minor loss in New Jersey and Maryland. Root-knot nematode losses are most heavy in the South.

Downy mildew, anthracnose, and angular leaf spot can be controlled fairly effectively by the application of fungicides. Seed treatment and rotation also are valuable in control of anthracnose and angular leaf spot. Varieties resistant to scab have been introduced, but control of scab on slicing cucumbers is still a difficult problem. Bacterial wilt rarely causes severe damage in any one field, and it can be controlled only by using insecticides to destroy the cucumber beetles that disseminate it. Losses from mosaic can be reduced by eradicating perennial weed hosts and use of resistant varieties. Rotation is the only means generally used for root-knot nematode control.

Cucumbers for Pickling

The major losses of cucumbers grown for pickling are caused by the cucumber mosaic virus and scab. Downy mildew, anthracnose leaf blight and fruit rot, and bacterial wilt cause minor losses. Root-knot nematodes cause considerable damage in the South.

About 60 percent of the pickling cucumbers are grown in the North Central States, particularly Michigan, Wisconsin, Indiana, Ohio, Minnesota, and Illinois. Another 25 percent are grown in Maryland, North and South Carolina, Georgia, Alabama, and Mississippi. California, Colorado, and Oregon produce most of the western crop. The relative importance of the various diseases is determined by the location. Mosaic is particularly prevalent in the North Central States. Bacterial wilt also is common there, but is rarely found in the South. Scab is very damaging in the northern tier of States from Minnesota to Maine, where large acreages of pickling cucumbers are grown, but is of little general importance farther South. Downy mildew is confined to the Atlantic Seaboard, and root-knot nematodes are most prevalent in the South.

Losses from mosaic and scab are likely to be reduced by the recent introduction of resistant varieties. Downy mildew and anthracnose can be fairly well controlled with fungicides. Rotation is still the chief means of reducing loss from root-knot nematodes.

Eggplant

The most important disease of eggplant is the fruit rot and leaf blights which occurs wherever the crop is grown, but is most damaging in the South. The crop in the South is also damaged by a killing of leaves and young branches by sclerotinia fungi, as well as by root-

knot nematodes. Verticillium wilt causes some loss in northern sections.

Fruit rot can be controlled by seed treatment, rotation, or the use of resistant varieties. Rotation is the only means of controlling the other diseases.

Escarole

The diseases causing loss of escarole are damping off, leaf decay, alternaria leaf spot, the leaf rot known as drop, and the yellowing and dwarfing caused by the aster yellows virus. The root-knot nematode causes some damage. All these diseases occur in Florida, where the crop is grown almost exclusively.

Damping off is controlled by chemical seed treatment and seedbed sterilization. Leaf disease losses and injury from root-knot nematodes can be reduced by crop rotation. The use of insecticides to destroy the insect vectors is the only means of control for aster yellows.

Kale

Disease losses of kale are caused mainly by clubroot, black rot, Fusarium yellows, and mosaic. All these diseases injure the edible leaves and stunt the plants wherever the crop is grown.

The only control for clubroot consists in using clean seedbed soil and growing the crop on clean land, although keeping the soil alkaline helps. Hot-water treatment of seed and crop rotation reduce losses from black rot. Rotation is the only means of avoiding loss from Fusarium yellows, as we have no resistant varieties of kale. No control for mosaic is known except isolation of the crop from sources of the virus.

Lettuce, Field-Grown

Field-grown lettuce is damaged rather severely by tipburn, a nonparasitic disease that causes a blackening of the leaf margins and discoloration of the large veins. Stunting of the plants by virus diseases, chiefly mosaic and aster yellows, is another cause of serious loss. Bottom rot and drop cause decay of the stems and leaves. Downy mildew causes a withering of the leaves but no rot. The root-knot nematode causes loss in warm regions.

Tipburn occurs wherever lettuce is grown. Mosaic is widespread, but aster yellows is damaging chiefly in the Northeastern States. Bottom rot and drop occur in most lettuce-growing areas, but drop is the more common.

Tipburn is a result of high-temperature injury to rapidly growing plants, and the only control seems to be the development of resistant

varieties. Mosaic is seed-transmitted, and losses could be reduced if growers could obtain mosaic-free seed. Rotation is of some value in reducing losses from bottom rot, drop, and nematode injury.

Melons

Losses in honeydew and honeyball melons are due largely to damage of the leaves by powdery mildew and stunting of the plants and reduced yields from infection by the cucumber mosaic virus and the squash virus. Recently there also have been losses from a disorder of unknown cause called crown blight. All these diseases are present in both Arizona and California, where nearly all the crop is grown.

Powdery mildew can be partially controlled with fungicides, but no satisfactory method has been developed for either mildew or the virus diseases.

Onions

Disease losses in onions are due chiefly to fungi that cause injury to the leaves or roots or decay of the bulbs. The smut fungus attacks seedlings and causes elongated black blisters on the leaves. Most of these plants die. On older plants there is killing of the leaves by downy mildew and purple blotch. Pink root kills many of the roots and reduces the size of the bulbs. Bulb rots in the field include Fusarium rot and white rot.

Onions are grown under many climatic conditions. Environment affects the development and spread of parasitic fungi, and the importance of some diseases varies with the region where the crop is grown. Smut is important only in the Northern States. Downy mildew is widespread but severe chiefly in California, Oregon, New York, and Michigan. Pink root is severe in the lower Sacramento and San Joaquin Valleys of California, in the Rio Grande Valley of Texas, and on muck soils of New York, Ohio, Indiana, and Michigan. Purple blotch and Fusarium rot are widespread. White rot is damaging in Louisiana and has been reported in Oregon, Kentucky, and Virginia.

Smut can be controlled by applying formaldehyde in the row as seed is planted and by applying chemicals to the seed. No satisfactory control has been developed for downy mildew or purple blotch. Losses from Fusarium rot and pink root can be reduced by crop rotation.

Peas, Green

The greatest loss in green peas is due to the various root-rot diseases, all general in occurrence except for southern wilt, which is restricted mostly to the South. Serious losses are caused also by the widespread ascochyta and bacterial blights. Powdery mildew causes some loss where climatic conditions favor it, chiefly in semiarid sections in the Rocky Mountain States. Fusarium wilt is

widespread but minor because of the use of resistant varieties. Virus diseases, especially mosaic, occur wherever peas are grown and cause appreciable damage. Root-knot injury is most severe on light soils in the South and parts of California.

The root rots are difficult to control, but losses can be reduced by crop rotation and planting on well-drained soils. The use of clean, western-grown seed treated with a fungicide, plus crop rotation, is the only means of controlling ascochyta and bacterial blights. Fusarium wilt is controlled by use of resistant varieties, and varieties resistant to the form known as near-wilt are being developed. Virus diseases are not successfully controlled.

Peppers, Green

Disease losses of peppers are due principally to leaf spots, fruit spots and rots, and mosaic virus infections. Bacterial spot causes a partially defoliating leaf spot and a spotting of the fruits. Cercospora leaf spot causes a drop of severely infected leaves, but does not spot the fruit. Anthracnose fruit rot causes less damage than the leaf spots, but is of economic importance. Tobacco mosaic virus is a major cause of loss. Cucumber mosaic virus also causes a stunting and reduction of yield in peppers. Southern blight causes minor loss, as do bacterial wilt and the root-knot nematode. Blossom-end rot of the fruit, a nonparasitic disease, also causes some loss.

Leaf spots and fruit rots occur wherever peppers are grown in humid areas. Virus diseases and blossom-end rot are present in all pepper-growing sections. The wilt diseases and root-knot injury are most prevalent in the South.

Seed disinfection and crop rotation help to reduce losses from leaf spot diseases, but fungicides applied as sprays have not been very effective. Anthracnose and virus diseases have not been satisfactorily controlled, although varieties resistant to tobacco mosaic virus have been developed. Rotation is the only means of avoiding losses from wilts and nematode injury. Little can be done to control blossom-end rot, since it is caused by a deficiency of soil moisture.

Potatoes

Potatoes are severely affected by disease in the field. Late blight causes foliage injury and tuber rot, which is a major cause of loss in many of the large producing areas in the Central and Atlantic States, and also at times in some sections of California. Early blight damages foliage and also causes some tuber injury wherever potatoes are grown in humid areas. It approaches late blight in reduction of the crop. Scab is another major source of loss except on highly acid soils. It occurs wherever potatoes are grown and causes a pitting and scabby condition on the surface of the tubers that

reduces the yield and market value of the crop.

Less severe but important losses result also from fungus and bacterial wilts and tuber rots. The most important fungus diseases are verticillium wilt, fusarium wilt, and the rhizoctonia disease. The bacterial diseases are blackleg and ring rot. Most of these diseases may occur wherever potatoes are grown, but they are particularly prevalent in the North Atlantic, North Central, and Pacific coast regions.

Virus diseases rank with late blight, early blight, and scab as a cause of losses in potatoes. Since the viruses are carried in seed tubers, they occur wherever potatoes are grown. Losses result from decreased yield and quality of tubers and increased cost of production due to the necessity of using certified seed that is so grown as to keep the plants comparatively free from infection. The more important virus diseases are the mosaic diseases, leaf roll, spindle tuber, yellow dwarf, and purple top.

Both late and early blight can be controlled fairly well by frequent applications of fungicides. Some varieties resistant to late blight are available. Scab losses can be reduced by use of clean seed, chemical seed treatment, and crop rotation. Tolerant varieties are available. Losses from wilts and tuber rots can be reduced by use of certified seed and crop rotation. Serious virus disease losses can be avoided by use of certified seed. Varieties resistant to certain viruses have been introduced.

The root-knot and meadow nematodes cause minor loss in yield and quality of tubers. Rotation helps to reduce damage.

Another nematode that is of great potential importance is the potato golden nematode, which occurs in this country only in a restricted area on Long Island, New York. This nematode attacks the roots, weakening and stunting the plants and consequently greatly reducing tuber yield. Loss estimates for it are not included in the tables because potato production on infested land is prohibited, but its destructiveness is shown by experience in Europe and on Long Island. It lives for years in the soil even in the absence of host plants; on badly infested land profitable potato crops can be produced only once in 5 to 8 years, and no method of eradicating it is known. Losses in heavily infested fields range from one-third up to almost three-quarters of the yield. The strictest possible measures to prevent further introduction and spread in this country are being enforced by Federal and State governments.

Shallots

The shallot crop is damaged by the same diseases that attack onions. Much of the loss is caused by pink root, downy mildew, purple blotch,

and the yellow dwarf virus. These diseases are all widely distributed in Louisiana, where most of the crop is grown.

None of these diseases are adequately controlled. Rotation and good cultural practices are of some help against fungus diseases. Yellow dwarf virus is carried in the bulbs but not in the seed. Therefore, plants grown from seed are not likely to be seriously damaged unless grown near plants produced from infected sets or grown from bulbs for seed.

Spinach

Spinach is severely affected by leaf blight, wilt, and virus diseases. Damping off is damaging to stands of seedling plants. Fusarium wilt causes loss in Texas and Virginia. Downy mildew damages the leaves and is a major cause of loss, particularly in humid coastal areas. White rust is epidemic in Texas, Arkansas, and Oklahoma, but has not caused losses elsewhere. The cucumber mosaic virus is particularly severe on fall and winter crops. The curly top virus causes heavy losses west of the Continental Divide and limits production in some areas; occasionally the disease appears also in southwestern Texas.

Damping off can be checked by treating the seed with fungicides. The use of resistant varieties has reduced losses from Fusarium wilt and cucumber mosaic. No satisfactory control is yet available for blue mold, white rust, or curly top. The development of resistant varieties appears to be the only means of controlling these three diseases.

Sweetpotatoes

Much of the loss of sweetpotatoes in the field is due to stem rot and wilt. Soil rot is a root disease that stunts the plants and causes heavy losses. Less severe losses are caused by black rot and scurf. Injury by the root-knot nematode and the meadow nematode causes considerable reduction in yield and quality. All these diseases occur wherever sweetpotatoes are grown in the United States.

The loss from wilt can be reduced by the use of clean seed potatoes and clean soil for bedding. Disinfection of the surface of roots used for seed also is important. Rotation and the use of clean seed stock are the only means of reducing loss from black rot. No adequate control measure for soil rot is known. Rotation helps to reduce nematode injury.

Tomatoes, for Processing

Tomatoes in the field are severely affected by wilt diseases, leaf spots, fruit rots, virus infection, root-knot nematodes, and nonparasitic diseases.

The most important wilt diseases are Fusarium wilt, which is prevalent throughout the warmer regions of the United States, and verticillium wilt, which is most serious in California and Utah. Bacterial wilt causes some loss in the South.

Defoliation by leaf spot diseases reduces yields and exposes the fruit to sunscald. Some leaf spots affect only the foliage and stems, while others also cause rot of the fruit. Septoria leaf spot and gray leaf spot are the chief diseases affecting only the leaves. Leaf mold causes minor loss. Early blight and late blight cause spotting of the leaves and rots of the fruit, although late blight is the most injurious as a fruit rot. This disease is always a major threat to tomatoes. Most of these diseases are widespread in humid areas east of the Continental Divide. Leaf mold, however, is prevalent chiefly in the South Atlantic States, and gray leaf spot has only recently spread from the South into the North Central and Middle Atlantic States.

Some fruit rots are caused by fungi that do not affect the leaves. The most important is anthracnose, which is destructive in tomatoes grown for processing in humid sections. Soil rot and buckeye rot cause minor losses.

Virus diseases affect tomatoes wherever they are grown. The tobacco mosaic virus causes some reduction in yield in most fields. Curly top virus is often very damaging to tomatoes west of the Continental Divide and sometimes causes loss in areas adjacent to the eastern slope of the Rocky Mountains. Its occurrence is restricted because it is transmitted by a leafhopper present only in semiarid areas in the West. Other virus diseases cause minor losses.

Blossom-end rot, a nonparasitic disorder due to high temperatures and lack of soil moisture, causes some injury throughout the United States.

Losses from Fusarium and verticillium wilts can be reduced by use of resistant varieties and crop rotation. No varieties resistant to bacterial wilt are available. Seed treatment and the application of fungicides are the chief means of controlling leaf spots and fruit rots, although there are varieties with some resistance to certain of these diseases. Virus diseases are not yet adequately controlled. Losses from nonparasitic diseases can be reduced by good cultural practices.

Tomatoes, for Fresh Market

The diseases causing the most serious losses of fresh-market tomatoes are generally the same as those damaging the processing crop. However, late blight is more damaging to the fresh-market crop, because much of it is grown in humid coastal areas of the South Atlantic and South Central States, where this disease is more

consistently prevalent. Certain other leaf spot diseases are also more injurious in these regions than on the processing crop, which is largely grown in less humid regions farther north. Fusarium wilt and bacterial wilt are more prevalent on the market crop grown in the South. On the other hand, anthracnose does not appear until tomatoes ripen and is less prevalent on the large portion of the fresh-market crop that is picked when green-mature. Virus diseases and nonparasitic disorders are equally prevalent on fresh-market and processing tomatoes.

The same measures are used to control diseases of fresh-market tomatoes and tomatoes grown for processing.

Watermelons

Severe losses of watermelons are caused by a few diseases. Fusarium wilt is present wherever the crop is grown and causes considerable loss, although a number of resistant varieties are available. Anthracnose is widespread in humid areas east of the Continental Divide. It causes a leaf spot that can defoliate the vines and a fruit spot that is injurious both in the field and in transit. Downy mildew causes serious damage in the Atlantic and Gulf States. Root-knot nematode injury is common, particularly on sandy soils in the Southern States.

Losses from wilt can be greatly reduced by the use of resistant varieties, but many popular ones are not wilt-resistant. Seed treatment, crop rotation, and application of fungicides help to reduce losses from anthracnose, but the disease is not well controlled. Spraying or dusting will check downy mildew, but is not very effective in humid weather. Rotation helps to avoid serious injury from root-knot nematodes.

Drug and Ornamental Crops

Estimates of disease losses to drug and ornamental crops (Table 5) have been restricted to commercial plantings. They do not include losses in home gardens and landscaping with the exception of shade trees.

China Asters

The China aster is an excellent annual for the garden as well as for commercial cut-flower production. Its use is curtailed by two serious diseases, Fusarium wilt and aster yellows, each difficult to control.

Wilt causes seedling blight, stem rot, and wilt of growing plants, and flower blight of China asters in transit. The fungus is generally distributed in the United States. It is seed-borne and can persist in infested soil for years. Resistant varieties are erratic in performance. Commercial producers of cut flowers treat seed and rotate or disinfect soil.

Yellows, a leafhopper-borne virus disease affecting many kinds of plants, is particularly damaging to China aster. Affected plants have yellowish leaves, many lateral branches with an upright habit of growth, green flowers, and no viable seeds. The disease is generally prevalent over the United States, occurring in a slightly different form westward. China asters for commercial cut flowers are nearly always produced under cloth to exclude the leafhopper vectors.

Chrysanthemums

Verticillium wilt, stunt, and leaf nematodes, carried in cuttings used in propagating chrysanthemums, have forced the business of propagation into the hands of specialists, who index and reselect plants free from such diseases for commercial growers. Their success in producing healthy propagation stock has greatly reduced losses in commercial greenhouse and shade-house chrysanthemums. Such reselection service is not generally available for garden varieties, and losses remain heavy for the amateur. Leaf spot causes heavy losses in wet seasons unless sprays are applied. Inroads of these diseases tend to discourage the amateur and thus lower the demand for garden varieties.

Leaf spot is characterized by yellowish spots on the leaves, becoming brown to black with black dots near the centers. In unprotected garden chrysanthemums severe defoliation follows in wet seasons. Commercial chrysanthemums are sprayed with ferbam when necessary, so that losses in these plantings are rarely important.

The leaf nematode causes leaves to wither and droop, marring the appearance and lowering the production of garden chrysanthemums, especially in wet seasons. Initial symptoms are yellowish spots in the leaves; later these spots enlarge and turn black, often being delimited by veins to form wedge-shaped areas. This nematode is widely distributed and damaging in gardens, but rare in commercial shade chrysanthemums, which are produced from selected disease-free plants.

Stunt, a virus disease, shortens the plants and reduces the size of the leaves and blooms. In some varieties stunted plants bloom earlier than normal ones, and some bronze- and pink-flowered sorts bear bleached or yellow blooms. The disease is widespread in garden chrysanthemums, but less prevalent in florists' varieties because of intensive work of reselection of disease-free stock.

Verticillium wilt is caused by a soil-borne fungus. Affected plants show yellowing and browning of leaves progressing from the lowermost upward, and sometimes dark streaks in the woody tissues of stems. Plants are killed or, in earlier stages of the disease, unproductive. In garden chrysanthemums this wilt is common and difficult to control. Commercial plantings under glass and under

Table 5. Losses Due to Diseases of Drug Crops and Ornamental Plants

Commodity and unit of production	Actual production 1/			Loss of production 2/			
	Quantity	Acreage	Value	Percentage	Quantity	Value	Acreage equivalent due to loss
	1,000 units	1,000 acres	1,000 dollars	Percent	1,000 units	1,000 dollars	1,000 acres
DRUG PLANTS							
Peppermint oil (Ore., Wash.) (lbs.)	589 3/	13 3/	3,359 3/	7.4 3/	47	268	1
Mint oil (Ind., Mich.) (lbs.)	1,148 3/	41 3/	5,835 3/	13.8 3/	183	934	6
TOTAL FOR DRUG CROPS	-	54	9,194	-	-	1,202	7
ORNAMENTAL CROPS 4/							
Chrysanthemums (outdoors and under glass, cloth)(blossoms plus bunches of pompoms)(No.)	53,794	-	17,693	11.0	6,649	2,187	-
Carnations(flowers and plants) (No.)	255,334	-	20,344	11.0	31,558	2,514	-
Gladiolus(flowers and corms) (No.)	507,238	-	18,689	20.0	126,809	4,672	-
Lilies (flowers, bulbs, and plants) (No.)	17,823	-	6,115	5/	3,688	1,355	-
Roses(flowers and plants) (No.)	391,459	-	31,579	12.0	53,381	4,306	-
Narcissus(flowers and bulbs) (No.)	69,475	-	1,998	10.0	7,719	222	-
China aster(flowers) (No.)	4,405	-	186	50.0	4,405	186	-
Shade trees (No.)	661,672	-	6,616,720 6/	1.0	-	66,167	-
TOTAL FOR ORNAMENTAL PLANTS	1,961,200	-	6,713,324	-	234,209	81,609	-

1/ See footnote 1 of Table 1.

2/ See footnote 2 of Table 1.

3/ Represents only part of total crop.

4/ Based on 1950 census data.

5/ All lilies (including Easter lilies) are reported to be subject to a 6% loss from Botrytis and Fusarium, and Easter lilies suffer an additional 14% loss from fleck and scorch.

6/ Value of a shade tree taken as $10, which is the estimated cost of replacement.

cloth shade outdoors are less subject to damage because of the use of wilt-free stock and soil rotation or disinfestation.

Carnations

Continuous greenhouse culture of carnations, now gaining in favor, reduces the danger of loss from alternaria blight and rhizoctonia stem rot. Steam treatment of soils and the use of disease-free cuttings should control bacterial wilt, fusarium wilt, and rhizoctonia stem rot. However, not enough disease-free cuttings are produced to supply the industry, and steam is not always available or not effectively applied, to prevent heavy losses from these diseases.

Alternaria blight causes leaf spots and branch and stem rot, the affected areas being dark with fungus growth. Plants set outdoors for the summer are severely injured in wet seasons and remain unproductive for months after benching in the greenhouse. Spraying outdoor carnations with ferbam or ziram gives partial control. In the greenhouse this blight is not a problem if water is kept off the carnation leaves.

Bacterial wilt in carnations may be recognized by grayish-green leaves, wilting and root rot, yellow streaks in conductive tissues, and stickiness of the diseased tissues. The causal bacterium is carried in cuttings and persists in contaminated soil. Damage is light in cool weather, but sudden and destructive in warm seasons. Heavy losses still occur in commercial production, but soil disinfestation between crops and use of wilt-free planting stock provide control. Shortage of wilt-free stock and recontamination of treated soil by tools and handling operations still keep this wilt in the front rank of carnation diseases.

Fusarium wilt causes young plants to die slowly and old plants to die a branch at a time. Brown streaks are found in conductive tissues, but the tissues are not sticky as in bacterial wilt. The fusarium may be carried in cuttings and, like the bacterial wilt agent, can persist in soil. Losses are most severe in warm soils. Soil disinfestation and the use of cultured wilt-free cuttings or of cuttings from wilt-free plants provide control.

Stem rot appears as soft, moist decay of the stem near the soil line. Carnation plants of all ages are attacked when the soil is warm and moist. The causal fungus is encountered in virgin soils. Indoor culture of carnations, soil disinfestation, and shallow planting to keep the stems dry are control measures.

Gladiolus

In recent years the gladiolus industry has expanded in spite of heavy losses due to disease. Large expenditures are involved in post-harvest and preplanting sorting and chemical treatment of

corms, in quick drying of corms after harvest, in rotation of fields, and particularly in replacement of stock from more favored areas. Nearly 200 million corms of the variety Picardy have been shipped into Florida since 1944, mainly to replace rotted corms. In spite of using the best available control measures, growers may lose 5 to 40 percent of susceptible varieties. Fusarium rot causes the greatest loss in warm soils; it is outranked by dry rot and botrytis in cooler areas.

Botrytis blight affects all parts of the gladiolus plant, causing severe damage in cool, moist weather. It causes corm rot in the Northern States when wet weather is encountered at harvesttime, a transit rot of flowers shipped from the Southern States, and damaging leaf spot and leaf rot in all growing areas during wet weather. The fungus is carried in the corms, and is capable of persisting in soil for years. Corm infection is minimized by curing the corms at 85°-95° F. after harvest. Infections in growing plants are prevented with fair success by spraying with zineb or nabam.

Curvularia blight first appeared on gladiolus in Florida and Alabama in 1947. It has since become general over the United States, and damaging in warm, moist weather. The fungus is carried in corms and persists in soil. Leaves and flowers are blighted; losses are most severe in young stock from seed or from cormels. Frequent spraying with nabam or zineb gives control; rotation of crops also reduces infection.

Fusarium corm rot occurs in the field and in storage wherever gladiolus are grown, causing heavy losses in warm soils in spite of the best available control measures. The fungus is corm-borne and persists in soils for years. Sorting and chemical treatment of corms, rotation of crops, and use of planting stock from more favored areas are practiced to hold fusarium in check.

Dry rot of gladiolus corms, associated with neck rot in plants in the field, is second only to botrytis blight in cool, moist climates. Losses can be kept down by sorting and fungicidal treatment of corms, quick curing of the corms at 85°-95° F. after harvest, and rotation of crops.

Lilies

Domestic production of Easter lilies is concentrated in the Southeast, where bulbs are produced for greenhouse finishing as cut blooms during the winter months, and in the Northwest, where bulbs are supplied for greenhouse finishing as Easter pot plants.

In the Southeast necrotic fleck, a virus complex transmitted by aphids, has sharply limited production. The disease is not recognizable in the bulbs, and has been widely distributed in planting stock. Fleck-diseased plants are unsalable. The industry survives by controlling aphids as well as possible, and by frequent replace-

ment of planting stock from uncontaminated areas, which are becoming scarce. Control of aphids with the new phosphorus insecticides delays spread of the disease. Production of disease-free planting stock by specialists in favored locations seems to be the logical control practice, but little use has been made of it.

In the Northwest necrotic fleck has been effectively excluded from commercial lily production areas, but the scorch disease, due to nutritional unbalance, has threatened the principal variety, Croft, grown in the region. It is manifest by an unsightly brown spotting in the leaves of forced lilies. The addition of lime to potting soils and side dressing with nitrogen fertilizers have given some control of the disorder.

The Easter lily and garden lilies are subject to attack by botrytis blight and fusarium rot. The use of the more susceptible lilies, such as Madonna and Testaceum, is sharply limited by these diseases.

Botrytis blight causes leaf rot and flower spotting of all species in cool, moist weather. Easter lily blooms intended for market are worthless when attacked. The causal fungus persists in debris from the previous crop, and in the overwintering rosette leaves of the Madonna lily. Copper sprays are used to reduce damage in the cool Northwest.

Fusarium rot causes losses in warm, moist soils. It appears as a firm brown rot of bulbs of many species and limits their use to the cooler soils. Control is difficult, but rotation of planting sites, sorting of bulbs, and treatment with thiram are measures in use.

Mint

Rust causes losses of peppermint in Oregon and Washington. Two hundred acres were involved in 1949, when a new race of rust appeared. In 1952 the disease affected 15,400 acres, destroying 7.4 percent of the crop. Affected leaves drop before harvesttime and the oil glands on the remaining leaves are destroyed. No satisfactory control measure is known. Many fungicides cannot be used because of contamination of the oil.

Verticillium wilt disease affects both peppermint and spearmint. It is prevalent in Indiana and Michigan, and a trace is now known to be present in Oregon. Affected plants are stunted, defoliated, and may be killed. Poor stands due to winter killing add to weeding costs. Wilt is present every year, but is most severe in hot and dry summers. No sprays, dusts, or chemical soil treatments have given practical control. Crop rotation is of some value.

Narcissus

Fusarium rot is a soft brown rot that starts at the basal plate of the narcissus bulb, spreads through the bulb and destroys it in the field or in storage. The fungus is carried in diseased bulbs and can persist for years in infested soil. Damage occurs wherever narcissus is grown, but is most severe in warm soils. Losses were extremely heavy in the early years of domestic narcissus production. Changes in varieties and in cultural practices and the development of fungicidal dips containing organic mercury compounds have decreased losses but have not eliminated them.

Roses

Blackspot occurs wherever roses are grown, causing leaf spots and defoliation, and contributing to dieback and winter injury. It is the chief disease of garden roses, and limits the use of hybrid tea roses in gardens. In all but the driest areas, regular spraying or dusting with sulfur-copper or sulfur-ferbam is necessary to hold blackspot in check. In wet seasons the most effective fungicides and proper timing of applications are important. On greenhouse roses, blackspot has nearly disappeared since miticides have come into use for control of spider mites.

Rose mildew, another fungus disease, appears as a white powdery coating on leaves, buds, and canes, with curling and distortion of leaves and buds. It is present each year on the susceptible rambler roses, and in humid weather it may also damage hybrid teas. In greenhouses mildew is troublesome especially in spring and fall when temperature fluctuations afford high humidity. Spraying roses in greenhouses is often necessary to prevent decrease in production and cull blooms. Spotting, staining, and sometimes burning produced by mildew fungicides add to the losses assignable to this disease.

Shade and Ornamental Trees

Over 1,000 species of native and introduced shade and ornamental trees are used in home grounds, on farmsteads, in parks, and along streets and highways. No species is immune to diseases. Some diseases kill the trees, some weaken them so that they are unsafe, and others kill the tops and reduce growth. Examples of killing diseases are Dutch elm disease, elm phloem necrosis, oak wilt, mimosa wilt, and cankerstain of London planetree. There are hundreds of canker diseases, wood rots, leaf diseases, and root diseases of shade and ornamental trees.

To protect shade trees from many of these diseases, a costly maintenance program of spraying, pruning, and fertilization must be conducted. No definite information is available on the total cost of protecting shade trees from disease and of replacing those killed or structurally weakened. A conservative estimate of the average cost

of removing one large dead tree and replacing it with a small tree is $10 to $20. In one large mid-western city the budget for shade-tree care was $340,000 in 1952. Almost 1,000 trees killed by Dutch elm disease had to be removed by the city. Losses from shade-tree diseases are continuous, but in a given locality may increase greatly for a few years when an epidemic such as Dutch elm disease strikes.

CHAPTER V. INSECTS ATTACKING CROPS

According to the Yearbook of Agriculture for 1952, approximately 10,000 species of insects in the United States are important enough to be called public enemies. About four-fifths of them are injurious to crops. Some cause heavy losses each year, but many are limited in distribution and cause only occasional or minor damage.

Estimates of the losses caused by insects in this country have been assembled by different workers at various times, but there is no adequate basis available for estimating the total loss by all destructive species. Such estimates as have been made concern only a few species, chiefly those of major economic importance. Persons attempting to make estimates soon find that they are faced with many variables and complicating factors which make the task a formidable one. For instance, the crop damage caused by one species differs from year to year and from one area to another. Furthermore, most insects of economic importance tend to appear in cycles of abundance. They may cause relatively little or fairly uniform damage for several years, followed by an upsurge of damage when they reach outbreak proportions.

Insects cause losses in many ways. They reduce the yield of crops, lower the quality and contaminate the marketed product, and increase the cost of producing, processing, or marketing it. They also transmit plant and animal diseases from infected to healthy crops and livestock. This chapter covers estimates on only the direct losses to crops. Estimates on losses caused by insects directly attacking animals are in Chapter X; those relating to diseases transmitted by insects are included in Chapters IV (Plant Diseases) and X (Livestock and Poultry); grasshopper damage to rangeland is discussed in Chapter VI; storage insects are covered in Chapter VII; forest insects are discussed in Chapter IX; and estimates of the costs of insect control are given in Chapter XII.

Today's insect losses to many crops differ greatly from those of a few years ago. Some pests, particularly those not native to this country, have spread to new areas and have thus extended their damage. Examples are the European corn borer and the Japanese beetle. Other insects have modified their habits, and have become pests of economic importance on new crops. For example, the green peach aphid did not become an important problem on tobacco until about 1946.

Changing agricultural conditions and practices also affect insect losses. Twenty years ago the tomato pinworm was a major pest of the tomato crop in southern California. In recent years, owing chiefly to changes in cultural practices which involve destruction of crop remnants, this insect has been of minor importance. With the development of new insecticides, beginning in 1945 when DDT was released to the public, the situation with respect to many insects has changed appreciably. The chlorinated hydrocarbon and organic

phosphorus insecticides have provided more effective tools for reducing damage by some insects. These materials have for the first time made it practicable to control insects on some crops. But along with their widespread use have come such complicating factors as resistance of certain pests to the materials that at first provided good control.

The estimates given in Tables 6, 7, and 8 can, at best, merely serve as examples of losses caused by insects. The losses shown in these tables total $989,080,000 for the selected insects attacking field, forage, fruit, nut, and vegetable crops, and $1,647,000 for those affecting ornamental roses. Based on these as a sample, it is the judgment of Department entomologists that the annual loss from the remaining several thousand species attacking crops and ornamental plants in the United States was nearly $951,000,000 additional, making total crop losses about $1,942,000,000 per year. Total annual losses to crops, livestock, forests, fabrics, households, and buildings from all insects have been estimated at $3,600,000,000, and the cost of control measures at $400,000,000.

In the paragraphs that follow are included notes about a number of insects on which loss data were too meager to be included in the tables.

Field and Forage Crops
(Table 6)

Alfalfa, Clover, and Other Forage Crops

Insects cause heavy losses to legume and grass crops, which have assumed increased importance with the added emphasis on grassland agriculture. Satisfactory estimates of the annual losses by some of these insects over the period 1942-51 are not available.

The meadow spittlebug on alfalfa and clover, which has become increasingly abundant in recent years, caused an annual loss of $52,230,000 in New York, New Jersey, Pennsylvania, Delaware, Maryland, Ohio, Indiana, Michigan, Illinois, and Wisconsin.

In 1941 it was estimated that lygus bugs were destroying 60 percent of the alfalfa seed crop in Utah. Since 1946, with the application of modern insecticides to control these bugs and other insects present on the crop, together with better use of pollinating insects, the yields of alfalfa seed in Utah, Arizona, California, Idaho, New Mexico, Oregon, and Washington have steadily increased.

The loss caused by the clover seed chalcid to seed alfalfa in Utah in 1952 amounted to $339,000, according to a cooperative State-Federal survey. Many of the seed growers believed that their losses due to this insect were two to three times as great the previous year.

Stink bugs are serious pests of alfalfa grown for seed in southern Arizona. In 1942 and 1943 the seed damage caused by these insects in that area was estimated at 1 and 3 percent, respectively. In some years, however, as much as 15 percent of the crop in parts of Arizona has been destroyed.

The potato leafhopper causes extensive losses to alfalfa and red clover each year in the eastern half of the United States. Losses in yield of alfalfa caused by this insect have ranged from 14 to 27 percent.

In California the alfalfa weevil, the alfalfa caterpillar, lygus bugs, the pea aphid, grasshoppers, spider mites, and leaf rollers reduce the annual production of alfalfa hay by 20 percent, or about 800,000 tons. At $25 per ton this loss would amount to $20 million.

Other insects of legume and grass crops destroy millions of dollars' worth of seed and forage every year. The more important of these additional pests are the clover root borer, the clover seed midges, the clover aphid, clover leaf weevil, clover seed weevil, vetch bruchid, thrips, webworms, white grubs, cutworms, armyworms, the corn earworm, harvester ant, chinch bug, and Rhodes-grass scale.

Insects Predominantly Injurious to Corn

Chinch bugs are very destructive to corn, sorghum, small grain (barley, wheat, rye, and oats), and other plants belonging to the grass family in the general region drained by the Mississippi, Ohio, and Missouri Rivers. Overwintering adults settle on small grains in the spring. The young bugs, or nymphs, which they produce, feed in the small grain and later migrate to corn or sorghum. They suck the juice from the plants, causing them to die.

During the period 1942-51, chinch bugs caused an annual loss of $951,000 to corn and sorghums in the United States. The loss in 1942 was approximately $3,860,000, and through 1945 it exceeded $1,000,000 annually. It was much less during the last 6 years of the period, however, and amounted to only $14,000 in 1951.

While especially serious on corn, chinch bugs are also very serious pests of lawns and other turf in the Northeastern and Southeastern States. In recent years they have been especially damaging to lawns of St. Augustine grass in Florida.

Damage by chinch bugs to corn or sorghums may be prevented by the timely use of insecticide barriers that destroy the insects as they migrate to these crops from maturing small grains. Some of the new insecticides are also effective in controlling the bugs in lawns or turf.

The corn earworm is a most destructive enemy of ear corn of all kinds. It attacks field corn, sweet corn, and popcorn. In addition,

Table 6. Losses Due to Insects Attacking Field and Forage Crops

Commodity, pest, and unit of production	Actual production 1/			Loss of production 2/			
	Quantity	Acreage	Value	Percentage	Quantity	Value	Acreage equivalent due to loss
	1,000 units	1,000 acres	1,000 dollars	Percent	1,000 units	1,000 dollars	1,000 acres
Alfalfa, for hay (pea aphid) (tons)	35,252	15,925	721,961	4.1 3/	1,492	30,580	646
Alfalfa, for seed (Lygus) (lbs.)	82,007	900	29,315	35.0 3/	44,158	15,800	315
Alfalfa and clover, for hay(spittlebug) (tons)	50,764	26,969	1,013,075	5.2	2,760	52,230	1,391
Cotton(bollweevil)(bales)	12,215	22,036	2,043,635	10.1	1,366	228,580	2,226
Cotton (other insects) (bales)	do	do	do	4.9	634	106,071	1,080
Sub-totals for Cotton	12,215	22,036	2,043,635	—	2,000	334,651	3,306
Barley(greenbug) (bu.)	295,299	13,487	326,490	0.4	1,156	1,279	53
Corn, field							
(earworm) (bu.)	3,036,380	88,024	4,146,062	1.2	36,218	49,454	1,038
(European corn borer)"	(3,036,380)	(88,024)	(4,146,062)	1.9	58,808	80,735	1,817
(S.W. corn borer) (bu.)	(3,036,380) 4/	(88,024)4/	(4,146,062) 4/	0.2	7,074	9,660	205
Corn and sorghum(chinch bug)	--	--	--	--	--	951	--
Oats (greenbug) (bu.)	1,324,614	43,953	981,495	0.6	7,517	5,750	248
Wheat							
(stem sawfly) (bu.)	1,088,548 4/	70,584 4/	1,943,821 4/	0.2	2,707	4,835	175
(Hessian fly) (bu.)	(1,088,548) 4/	(70,584) 4/	(1,943,821) 4/	0.9	9,389	16,826	597
(greenbug) (bu.)	(1,088,548)	(70,584)	(1,943,821)	0.9	10,377	18,530	666
Sub-totals for grains	5,744,841	216,048	7,397,868	- -	133,246	188,020	4,799

Grasshoppers 5/ on grain and hay	-	(294,870)	(9,519,046) 6/	0.2	-	18,355	560
Sugarcane (borer) (tons)	6,281	316	37,407	9.4	650	3,871	30
Tobacco (all insects) (pounds)	1,948,844	1,677	881,868	11.0	240,868	108,995	184
TOTAL FOR FIELD AND FORAGE CROPS	-	283,871	12,125,129	-	-	752,502	11,233

1/ See footnote 1 of Table 1.

2/ See footnote 2 of Table 1.

3/ Estimates of losses from pea aphid and lygus on alfalfa apply to 1944 only and are based on a survey made at that time. It is believed that losses since then have been reduced materially by the use of insecticides.

4/ Represents total U. S. crop, although only part is in infested area.

5/ Grasshoppers are general feeders. These estimates are based on losses to corn, wheat, oats, barley, rye, and all hay. Grasshopper damage to range land is discussed in Chapter VI.

6/ Represents the value of grains and hay crops listed in footnote 5.

it infests sorghums, alfalfa, peanuts, tobacco, vetch, soybeans, cotton, tomatoes, and other vegetable crops.

Larvae of the corn earworm feed on the buds or central shoots of young corn plants, stunting them and reducing the yield. Later the worms go down through the silks of the ears and destroy many of the kernels. Sometimes they chew off the silks and prevent pollination. Their feeding in the ears also allows the entrance of molds, which increase the total damage.

During the period 1942-51 the corn earworm caused an annual loss of $49,454,000 to field corn, and $3,910,373 to sweet corn. Sufficient information is not available to make estimates of losses by this insect to other crops.

On field corn insecticides have not yet proved practical for control of the earworm. Injury can be reduced, however, by growing strains with long, tight husks and, when possible, by planting hybrids that possess some earworm resistance. On the other hand, sweet corn can be protected by spraying with an insecticide. With such control this crop can now be grown profitably in Florida and Texas in areas where previously the ears were so severely injured that they could not be marketed. Florida's present $10 million sweet corn industry depends on control of the corn earworm with insecticides. Several of the newer varieties of sweet corn possess considerable earworm resistance.

The European corn borer has become one of the most injurious enemies of field and sweet corn in the United States. Since it was discovered in Massachusetts and New York in 1917, it has spread westward, and by 1952 it had infested the entire Corn Belt, reached the eastern edges of Colorado and Montana, and had dispersed southward as far as northeastern Oklahoma, Arkansas, northern Mississippi, Alabama, Georgia, and South Carolina.

In its attack on field corn, the European corn borer reduces the yield and increases the cost of harvesting by causing broken stalks, poor ear development, and dropped ears. When it infests sweet corn the ears are often unmarketable, and costs of processing infested ears in the canning factory are greatly increased. In certain areas in years of heavy borer infestation, sweet corn cannot be grown profitably unless insecticides are applied.

The European corn borer caused an annual loss of 58,808,000 bushels of field corn, valued at $80,734,710, during the period 1942-51. Maximum damage occurred in 1949, when the loss amounted to 313,819,000 bushels worth $349,635,000. The annual loss to sweet corn was $3,847,157, or approximately 4 percent of the total loss to both field and sweet corn.

The European corn borer can be controlled with an insecticide. One or two applications are needed on heavily infested field corn, and

four or five on sweet corn. Over the 10-year period corn growers spent at least $13,900,000 on insecticidal control of the corn borer. The Federal and State Governments expended approximately $300,800 from 1948 to 1951 in service surveys that contributed to control.

The southwestern corn borer is a pest of corn in parts of Kansas, Oklahoma, Texas, New Mexico, Colorado, and Arizona, and in a few counties in Arkansas and Missouri. The loss increased from $2 million in 1942 to $22 million in 1951, averaging $9,660,000 annually.

The larvae feed on the leaves of the young corn plants, retarding their growth. They also damage the ears, and tunnel in the stalks, weakening, stunting, and sometimes killing the plants. This girdling and tunneling in the lower part of the stalks in the fall causes many plants to fall over, and their ears are lost at harvesttime.

Control of this pest is difficult. Insecticides have not proved practical, but certain cultural practices are of some help in reducing damage.

Cotton

The reduction in cotton yield caused by the boll weevil has been estimated by the Bureau of Agricultural Economics annually since 1909. The average reduction in yield for the 13 States where this weevil normally causes damage has been 10.1 percent. These States are Virginia, North Carolina, South Carolina, Georgia, Florida, Missouri, Tennessee, Alabama, Mississippi, Louisiana, Texas, Oklahoma, and Arkansas. Damage varies greatly between States and also between years. In Missouri, for instance, damage was recorded in only 9 of the 44 years, and the highest loss was only 7 percent in 1918. In Virginia, on the other hand, there was an estimated loss of 63 percent in 1950.

To the direct loss must be added the cost of control. This amounted to $3,200,000 annually during the 5-year period 1926-30, when calcium arsenate was the only insecticide recommended and when only a small portion of the total cotton acreage was treated. Since 1947, when the organic insecticides came into general use, a much larger portion of the total acreage has been treated. In 1952, a year of light insect damage to cotton, the cost to farmers of insecticides for the control of all cotton insects was $75,000,000, the greater part of which was for boll weevil control.

The costs of machinery and of custom application of the insecticides are also large. Many thousands of farmers own their spraying or dusting equipment, costing many millions of dollars. Custom applications by airplanes have greatly increased during recent years. The average cost of applying insecticides to cotton in this manner is about $0.50 per acre for dusts and $0.75 for sprays.

The damage to cotton caused by insects other than the boll weevil ranges from 1.6 to 8.9 percent in the boll weevil area and from 2.9 to 10.1 percent in the western irrigated areas where the boll weevil does not occur. These insects include the pink bollworm, bollworm, tobacco budworm, southern armyworm, yellow-striped armyworm, cotton aphid, cotton fleahopper, cotton leafworm, tarnished plant bug, rapid plant bug, conchuela, and several species of stink bugs, thrips, lygus bugs, grasshoppers, root aphids, leaf miners, flea beetles, darkling beetles, leaf-feeding lepidopterous larvae, and spider mites.

The annual loss caused by insects other than boll weevil amounts to $106,071,000. To this direct loss must also be added the cost of control. It is customary to apply combinations of insecticides to control two or more cotton insects at the same time. Therefore, since one insecticide may control the boll weevil and several other insects as well, it is difficult to estimate this cost. Probably the cost of controlling these insects as compared to the boll weevil would be close to the ratio of estimated reductions in yield, or 4.94 to 10.06. On the basis of the 1950-52 estimate of $47,138,000 spent annually for insecticides used on cotton, this ratio would indicate that $31,613,885 was spent to control the boll weevil and $15,524,115 to control other insects.

The annual cost of applying insecticides to cotton for the 3-year period 1950-52 has been estimated at $19,897,500. This estimate is based on the prevailing costs of applying the insecticides by custom operators. Custom application is about as cheap as farmer application when the costs of equipment, labor, and depreciation are taken into consideration.

Peanuts

The southern corn rootworm annually destroys at least $2 million worth of field-cured peanuts grown on heavy soils in the Virginia-Carolina-Tennessee area. Recent use of soil insecticides to control the pest in Virginia has increased the yields of peanuts as much as 40 percent and the return by an average of $50 per acre.

The velvetbean caterpillar, frequently destructive in the Southeastern States, one year cost Alabama peanut growers over $2 million. In another year the pest practically destroyed Florida's velvetbean crop, and in some years it has ruined the soybean crop in Louisiana.

Rice

The most important pests of growing rice in the United States are the rice stink bug, two stalk borers, and the sugarcane beetle. The rice stink bug causes an annual loss of approximately $1,500,000 and the other insects about $500,000 to rice grown in Louisiana, Texas, and Arkansas. Occasionally a leaf miner becomes a serious

pest of the crop in California. An outbreak occurred in 1953, and the California Agricultural Experiment Station estimated that this insect destroyed 10 to 20 percent of the crop, causing a probable loss of $16,000,000. In addition $1,200,000 was spent on insecticides.

Small Grains

Greenbugs frequently cause extensive losses to wheat, oats, and barley, in various parts of the Great Plains from Texas north to Canada. However, in some years they do little damage. They suck the sap from the plants, causing the leaves to turn yellow. In heavy infestations the leaves soon wither and the plants die. During the period 1942-51 they caused an annual loss of about $18,530,000 to wheat, $5,750,000 to oats, and $1,279,000 to barley, or a total of $25,559,000.

In recent years new insecticides have given excellent greenbug control. During outbreaks in Oklahoma in 1950 and 1951 about 2,400,000 acres of small grains were treated.

The hessian fly, distributed over the North Central and Northeastern States, a portion of the Southern States, and within limited areas in California, Oregon, and Washington, is the most destructive insect enemy of wheat in the United States. Local outbreaks occur nearly every year, and widespread damage can be expected at irregular intervals, sometimes as often as every 5 or 6 years. The annual loss during the period 1942-51 is estimated at 9,389,000 bushels of wheat valued at about $16,826,000. The greatest loss occurred in 1946 when 14,932,000 bushels were destroyed by the pest.

In the fall the fly maggots suck the juices of the young plants, killing them outright or weakening them so that they cannot survive the winter. In the spring they kill the plants in the same way and also cause the stems to break so that the heads are missed by the harvesting machinery. Serious damage can be prevented by seeding wheat on fly-free dates in the fall, by planting fly-resistant varieties whenever possible, and by adopting other recommended cultural and cropping practices. A satisfactory control of the hessian fly with insecticides has not yet been developed.

The wheat stem sawfly is an important pest of wheat in the northern Great Plains. It occurs throughout North Dakota, in Montana as far west as the Rockies, over much of the western two-thirds of South Dakota, in nine counties in northwestern Nebraska, and in nine counties in eastern and southern Wyoming. It is a pest of native grasses that has found wheat a favorable host. On the basis of State reports and field surveys, it is estimated that over the period 1942-51 this sawfly caused an annual loss in Montana and North Dakota of 2,707,000 bushels of wheat, valued at about $4,835,000. In 1951 the loss amounted to 4,918,484 bushels, worth approximately $10,207,272. Loss in the other States has been much less important

and is not considered in the present estimates. Losses due to this sawfly are caused by reduced weight of the wheat kernels from tunneling of the stems by the sawfly larvae, and the breaking over of stems girdled by the insect. When the stems are broken, the wheat heads cannot be recovered during harvesting.

Control of the sawfly depends on such cultural practices as early harvesting, shallow cultivation or deep plowing, crop rotations, and the use of resistant crops. Insecticides have not proved practical.

Grasshoppers

Since pioneer days grasshoppers have caused extensive losses to crops and rangeland in the United States (for losses to rangeland by grasshoppers see Chapter VI). Throughout the growing season, these insects feed on small grains, corn, cotton, flax, alfalfa and clovers, and other crops. They reduce yields by defoliating the plants, biting off grain heads, flax and cotton bolls, and interfering with pollination by eating corn silks and the flowers of alfalfa and clovers.

Hundreds of species of grasshoppers occur in the United States, but many of them are of little economic importance. Five of the most important species attacking crops west of the Mississippi River are the migratory grasshopper, differential grasshopper, two-striped grasshopper, red-legged grasshopper, and the clear-winged grasshopper. The devastating grasshopper sometimes attacks crops in California. Over the period 1942-51, these species caused an estimated annual loss of about $18,000,000 to crops. During the same time, crops worth an estimated $35,000,000 were saved annually by the application of control measures.

In the Southeastern States the American grasshopper is a serious crop pest, and throughout the rest of the country east of the Mississippi River several species of grasshoppers do a large amount of damage to crops. No satisfactory data are currently available which would permit a reliable estimate of this loss.

The control of grasshoppers has changed completely during the last few years. New insecticides applied as sprays or dusts have replaced poison baits, providing more effective kills, even with low dosages of the toxicant. Today an application of only 2 ounces of aldrin in one gallon of oil per acre practically eliminates the infestation. In addition, aircraft and ground equipment have been improved to provide more efficient and economical means for applying the insecticide over large areas.

Sugar Beets

Sugar-beet crops are attacked by many insects. The most destructive is the beet leafhopper, the only carrier of the curly top virus. Direct damage by this leafhopper is usually negligible, but

sugar-beet production in many areas is possible only by the use of lower yielding varieties that are resistant to curly top.

The other insects that attack sugar beets are usually either spotted in distribution or sporadic in occurrence. They include the beet webworm, sugar-beet root maggot, sugar-beet root aphid, and various plant bugs, wireworms, cutworms, armyworms, grasshoppers, white grubs, and flea beetles. Fairly satisfactory control measures are now available except for the beet leafhopper. There is no satisfactory basis for estimating losses to sugar beets from these insects.

Sugar Cane

The sugar cane borer is the most injurious insect attacking sugar cane in the United States. The annual loss to the crop grown for sugar and seed in Florida and Louisiana over the period 1942-51 averaged 650,000 tons of cane valued at approximately $3,871,000. This loss represents about 9.4 percent of the potential production in the country. These estimates are based on the percent of bored sugarcane joints found in annual harvesttime surveys. In addition, the insect attacks corn, rice, and sorghums, causing large additional losses for which estimates are not available.

Young larvae of the sugarcane borer bore into the young plants, destroying the central tissues and causing dead hearts. In older plants the borers attack the stalks near the tops, causing dead tops, and tunnel in the stalks, weakening them so that they break over. Tunneling by the borer also causes a loss in weight and sucrose and injures seed cane.

Control measures consist of the destruction of overwintering borers in cane trash, planting resistant varieties of sugar cane, parasite introduction, and use of insecticides.

Tobacco

Tobacco in plant beds is damaged chiefly by cutworms, flea beetles, green June beetle larvae, and vegetable weevils. Before the young transplants become established in the field, they are often killed or stunted by wireworms, flea beetle larvae, and cutworms in the soil, and by flea beetle adults on the foliage. The older plants are damaged by hornworms, the tobacco budworm, and aphids. Grasshoppers, the corn earworm, the garden fleahopper, the suckfly, and thrips occasionally cause damage. Damage by aphids was unknown prior to 1946. The vegetable weevil was first reported on tobacco in Florida in 1937, and has been spreading to other areas. In 1940 the loss due to these insects was estimated, without any reliable basis, as about 11 percent, and there has probably been little change since then. During the period 1942-51 the annual loss to tobacco by all insects is estimated to have averaged about $108,995,000.

Fairly satisfactory control measures are available for all these insects.

Fruit and Nut Crops
(Table 7)

Apples and Pears

In the absence of control measures, the losses due to the codling moth range from 10 to 20 percent in the extreme northern apple- and pear-producing areas, to a near total loss in most other producing areas in the United States. For many years lead arsenate was the standard insecticide, but despite its extensive and intensive use, losses were heavy in many areas, often reaching 50 percent or more. Since 1946, DDT has been the standard insecticide, and through its use losses have been held to a low level, generally around 1 to 5 percent. In the last year or so injury has increased in some localities. It has not been determined whether this is due to more favorable conditions for the insect or to the development of resistance. Damage to pears is generally less serious than to apples. Walnuts are also subject to attack by the codling moth.

Based on a knowledge of the problem and records of damage in experimental plots in four representative localities, it is conservatively estimated that the average annual loss of crop, in spite of control measures, during the period 1942-1951 was about 11 percent, or nearly $28,427,000 in apples and $7,712,000 in pears.

Apples grown in the Northeastern and Great Lakes States are often rendered nearly worthless by the tunneling of the apple maggot. According to data presented at the meeting of the North Central States Branch, Entomological Society of America, March 19-20, 1953, the heaviest damage ($600,000) by the maggot in the North Central States occurred in Wisconsin in 1952. The estimated loss in these States for 1952, including money spent in control, was well over $1,500,000. Annual losses would be somewhat greater in New York and New England. The annual loss due to the apple maggot in the area of infestation, estimated on the basis of the above report and general information and observation, is 3 percent and amounts to about $4,200,000. This maggot is also a serious pest of blueberries, but there is no basis for estimating the loss to or cost of treatment of this crop on account of it.

Citrus

Scale insects, mealybugs, aphids, thrips, and mites are the major pests of citrus. They may seriously affect the set of fruit and lower the productiveness of the trees for several years, as well as reduce the quality and grade of fruit. In California and Arizona a tree may never fully recover from a heavy infestation of the California red scale. Citrus losses in California caused by insects, in spite of control measures, might equal the annual cost of control, which averages about $7,053,000.

In Florida, estimates place the annual damage to citrus by rust mites, scale insects, mealybugs, and whiteflies at $24,419,000, or 14 percent of the value of the crop, 6 percent of which is due to the rust mite. Similar losses occur in other eastern Gulf Coast States.

The Mexican fruit fly was first found about 1903 near Brownsville, Tex., and in 1927 infestations were discovered in the Lower Rio Grande Valley. It is of economic importance to the United States because of its habit of annually migrating across the border into the citrus of southeastern Texas. The Mexican fruit fly originally fed on a nonedible fruit native to northeastern Mexico, but with the introduction of citrus, mangoes, and several deciduous fruits adapted itself to them. It is now a pest of grapefruit, oranges, mangoes, peaches, apples, pears, and quinces. The flies deposit eggs in mature fruit, which the larvae feed on and destroy. At present, the pest is confined in the United States to eight counties in the Lower Rio Grande Valley. Loss to the citrus crop on the infested properties under quarantine is about 10 percent.

Figs (Dried)

The dried-fruit beetle and associated species are pests of figs in California, entering the fruit when it is approaching maturity on the tree. There is no known satisfactory method of control. Besides the direct effect of the infestation, these insects are the means of introducing numerous microorganisms that cause spoilage. Infested figs cannot be marketed for human consumption, but are disposed of for stock feed. Representatives of the fig industry place losses due to these beetles at 25 percent of the value of the crop. This would be an annual loss of about $1,500,000.

Japanese Beetle

The Japanese beetle has been observed feeding on more than 200 different farm, field, and fruit crops, ornamentals, and shade trees, eating only the foliage of some and the foliage, flowers, and fruit of others. Where infestation is light the damage may not be serious, but when beetles are numerous all leaf tissue on the favored plants may be consumed, and the fruit may be completely destroyed, made unmarketable, or reduced in value. In addition, the grubs feed on roots, causing severe turf damage in heavily infested sections.

The beetle probably gained access to this country in soil with plants prior to import restrictions of 1912. It was first found in 1916 near a nursery in Riverton, N. J. It is now generally distributed in all or parts of 15 eastern States from Massachusetts to North Carolina. Small numbers occur in scattered locations in other States as far west as the Mississippi Valley, and the pest is a potential threat to the remainder of the United States.

The damage to crops, residential and public plantings, and golf courses in the Eastern States is believed to be in excess of

Table 7. Losses Due to Insects Attacking Fruit and Nut Crops

Commodity and unit of production	Actual Production 1/			Loss of production 2/			
	Quantity	Acreage	Value	Percentage	Quantity	Value	Acreage equivalent due to loss
	1,000 units	1,000 acres	1,000 dollars	Percent	1,000 units	1,000 dollars	1,000 acres
Apples (codling moth) (bu.)	128,000	1,500	230,000	11.0	15,820	28,427	165
Apples (maggot) (bu.)	(60,000) 3/	(1,200) 3/	(140,000) 3/	4/	-	4,200	24
Figs (all insects) (tons)	32	-	6,000	25.0	8	1,500	-
Peaches (oriental fruit moth and plum curculio) (bu.)	29,639 5/	662 5/	47,462 5/	9.0 6/	2,931	4,694 6/	60
Pears (codling moth) (bu.)	30,396	176	62,398	11.0	3,757	7,712	19
Pecans (shuckworm, case-bearer, & weevil) (lbs.)	126,518	202	27,139	25.0	42,173	9,046	51
Japanese beetle damage to fruits and vegetables	7/	7/	7/	-	9/	10,000	59 8/
Sub-totals for non-citrus fruits	--	2,540	372,999	-	-	65,579	378
Citrus (various insects) (Florida) (boxes)	85,000	412 10/	150,000	14.0	13,837	24,419	58
Citrus (scale insects) (California and Arizona) (boxes)	66,000	320 10/	134,000	5.0	3,474	7,053	16
Sub-totals for citrus fruits	-	732	284,000	-	-	31,472	74
TOTAL FOR FRUIT AND NUTS	-	3,272	656,999	-	-	97,051	452

1/ See footnote 1 of Table 1.
2/ See footnote 2 of Table 1.
3/ Only that part of the U. S. crop which is in infested area.
4/ Loss in value from apple maggot was estimated at 3%.
5/ Only from the areas east of the Rocky Mountains.
6/ Loss in quantity from plum curculio on peaches was 4%.
7/ Acreage and crop values are shown in Tables 3 and 4.
8/ Loss in value from insects other than Japanese beetle on noncitrus crops was $54,079,432 and the acre-equivalent was 318,546 acres; in the same proportion, the loss of $10,000,000 due to Japanese beetle would represent an acreage equivalent of 58,903 acres.
9/ Not estimated.
10/ Citrus acreage estimated by dividing U. S. total among 3 areas in proportion to production.

$10 million annually. In addition to this direct loss, large sums are expended by State and Federal agencies, nurserymen, and private individuals to control the beetles and to enforce and comply with quarantine regulations to retard and prevent their spread.

Peaches

Hall scale infests the bark, twigs, leaves, and fruit of deciduous fruit and nut trees. It was introduced into California prior to 1934 and is known to attack almond, peach, apricot, nectarine, plum, pear, apple, and cherry trees. Although now confined to a limited area in Butte and Yolo Counties, it is a potential pest in all stone-fruit sections of the United States.

One heavy infestation on peach trees caused a 25-percent loss to a 12-acre orchard each year for 3 years in spite of an intensive spray program. In addition to the serious losses resulting from the killing of fruit spurs and reduction in grade, control costs amounting to approximately $25 per acre per year would be necessary to effect control if the insect became strongly established.

The peach crop east of the Rocky Mountains suffers heaviest losses due to the plum curculio, but apples, cherries, plums, and pears often suffer considerable injury. With the advent of more effective insecticides than lead arsenate, the insecticide formerly depended upon for control, former estimates of annual losses of 15 percent of the crop appear much too high. Data from Georgia and experimental plots in other major producing areas indicate current losses of about 5 percent.

No satisfactory estimates of losses due to curculio injury to apples, cherries, plums, and pears are available. However, damage to apples would be not more than about 1 or 2 percent.

The oriental fruit moth formerly damaged from 20 to 50 percent of the peach and quince crop. Use of the new insecticides has reduced this loss by 80 to 90 percent or more; in fact, use of parathion for curculio control may hold oriental fruit moth damage to a low level without further spraying. For the period 1942-51, the annual marketable peach crop east of the Rocky Mountains was reduced by 4 percent because of the oriental fruit moth.

Pecans

Nearly every year the size and quality of the pecan crop are markedly reduced throughout the Pecan Belt by the feeding of the hickory shuckworm, an insect for which there is no practical method of control. Evidence secured in 1952 indicates that the effect of its feeding on nut quality may be much greater than has been realized. The pecan nut casebearer causes heavy losses in some

years and some loss every year, and the pecan weevil causes serious losses in scattered orchards every year. The annual reduction in the size and quality of the pecan crop due to these insects is 25 percent, 15 percent for the shuckworm and 5 percent for each of the other insects. This is an annual loss of $9,046,000.

Vegetable Crops
(Table 8)

Beans

Bean crops of all kinds, whether for processing, fresh market, seed, or for sale as dry edible beans, are damaged by insects. Root maggots and wireworms attack the sprouting seeds and young plants before they emerge. Cutworms and the southern cornstalk borer attack the stems of the young plants. The Mexican bean beetle, leafhoppers, aphids, spider mites, thrips, leaf miners, cucumber beetles, slugs, and various caterpillars attack the foliage. In some areas the bean pods are damaged by the corn earworm, the bean cutworm, and lygus bugs. In California the lima-bean pods are attacked by the lima-bean pod borer. In the South the canning crop of cowpeas, or blackeye beans, is damaged by the cowpea curculio, which feeds within the immature seeds and may cause them to be rejected for processing. During the period 1942-51 the major losses were probably caused by root maggots, wireworms, the Mexican bean beetle, leafhoppers, and spider mites. The lima-bean pod borer caused little damage during this period.

The development of control measures for irrigated-land wireworms and the potato leafhopper greatly reduced losses due to these insects. However, losses due to root maggots, spider mites, and aphids increased, and available control measures were inadequate. The Mexican bean beetle continued to spread and caused heavy losses in spite of fairly satisfactory control measures. Direct annual loss to bean crops due to the Mexican bean beetle has been estimated at $3,593,000. No reliable data, however, are available on the total losses to beans by all insects.

Cole Crops

Cabbage, cauliflower, broccoli, brussels sprouts, turnips, kale, and mustard are severely damaged by about the same insects. Losses are particularly heavy in the southern part of the country. During the period 1928-32, cabbage caterpillars alone reduced the yield of marketable cabbage from 3 to 30 percent in different parts of the United States, or an average of about 20 percent. Since that time these losses have been reduced by improved control measures to approximately 8 percent, or about $7,902,000 annually.

In addition to more than a dozen caterpillars, the harlequin bug, vegetable weevil, and several species of root maggots, wireworms, leaf beetles, and aphids attack cole crops. Control measures are

Table 8. Losses Due to Insects Attacking Vegetable Crops and Ornamental Plants

Commodity and unit of production	Actual production 1/			Loss of production 2/			
	Quantity	Acreage	Value	Percentage	Quantity	Value	Acreage equivalent due to loss
	1,000 units	1,000 acres	1,000 dollars	Percent	1,000 units	1,000 dollars	1,000 acres
INSECTS ATTACKING VEGETABLE CROPS							
Beans, fresh lima and snap (Mexican bean beetle) (tons)	296 3/	233 3/	36,333 3/	9.0 3/	29	3,593	2
Cole crops (caterpillars) (tons)	1,599	230	90,879	8.0	139	7,902	18
Onion (thrips) (sacks)	40,132	135	51,399	17.0	8,220	10,527	23
Peas, dry (weevil) (bags)	5,998	498	25,418	2.4	150	636	12
Potato (psyllid) (bu.)	(411,007) 4/	(2,318) 4/	(551,789) 4/	0.6 4/	2,390	3,209	13
Potato (other insects)"	411,007	2,318	551,789	15.0	72,530	97,374	348
Sweet corn (earworm and European corn borer) (tons)	1,736	681	59,237	11.6	228	7,757	79
Sweet potatoes (weevil) (bu.)	46,198	495	100,659	1.7	798	1,740 5/	8
Tomato (hornworm and fruitworm) (tons)	2,377	458	141,348	4.5	112	6,660	21
Tomato (psyllid) (tons)	107 6/	13 6/	3,105 6/	4.0 6/	4	129	1
TOTAL VEGETABLE INSECTS	-	5,061	1,060,167	-	-	139,527	525
INSECTS ATTACKING ORNAMENTAL PLANTS							
Rose, greenhouse (spider mites) (flowers & plants)	390,353	-	31,296	5.0	20,545	1,647	-
Shade trees (all insects) (No.)	661,672	-	6,616,720 7/	-	-	75,000	
TOTAL FOR ORNAMENTAL PLANTS	1,052,025	-	6,648,016	-	20,545	76,647	

1/ See footnote 1 of Table 1.
2/ See Footnote 2 of Table 1.
3/ Only that part of the crop that is in the infested area, viz., Arizona, New Mexico, Colorado, and States east of the Mississippi River except Michigan, Wisconsin, and Florida. The production figures include fresh market green lima beans in shell, processing green lima beans shelled, and fresh market and processing snap beans in shell.
4/ Represents total U. S. crop although only part is in the infested area.
5/ Loss represents period of 1946-51.
6/ Production and loss figures relate only to that part of the crop that is in the infested area.
7/ Value of a shade tree taken as $10, which is the estimated cost of replacement.

available but need to be improved, particularly for the cabbage aphid.

Onions

The most destructive pests of onions are the onion thrips, which draws the sap from the leaves and damages the blossoms, and wireworms and the onion maggot, which feed on the bulbs. Any one of these insect species may cause crop failure. Prior to 1946 no satisfactory control measures were available, and the damage by the onion thrips alone was estimated at about 27 percent of the crop. Since that time the widespread use of DDT has greatly reduced these losses. For example, growers of onion seed report that under conditions of heavy thrips infestation they could produce from 200 to 400 pounds of seed per acre before DDT was used, but by using DDT they can produce from 1200 to 1500 pounds. The yield of bulb onions has been increased as much as 10,000 pounds per acre. On the basis of these increased yields, it is estimated that the loss due to onion thrips was reduced to about 10 percent during the period 1946-51. The average loss for the period 1942-51 was about 17 percent, or about $10,527,000 annually. No data are available on losses from wireworms or the onion maggot.

Peas

The pea aphid is the major widespread pest of peas in the United States. It sucks the sap from the leaves and transmits several mosaic diseases. In 1938 it caused losses ranging from 5 to 40 percent in different parts of the country.

Some of the other insects that damage peas, usually in limited areas, are the pea weevil, pea moth, beet armyworm, cutworms, seedcorn maggot, thrips, and leaf miners. The pea weevil is probably the most important, as its grub feeds in the immature seeds, making the green and dry edible peas unsuitable for the market and the seed peas nonviable. Pea weevil damage is limited chiefly to areas where large acreages of peas mature in the field. In Washington and Oregon where most of the dry edible peas are grown, the loss amounts to 2.4 percent of the crop, or about $636,000 each year. In addition, it costs about $124,000 annually for insecticides, and $90,000 for application. The annual loss from damage to the vines by application equipment averages about $180,000.

Peppers

Peppers are attacked by many of the insects that attack tomatoes and potatoes. The principal pests are cutworms, flea beetles, and the green peach aphid. The pepper weevil, which formerly was very destructive in California, caused relatively little damage during the period of 1942-51 owing to improved control measures estimated to have given California growers a net profit of $594,000 in 1941 alone. However, this weevil spread to Georgia during the period.

Potatoes

The potato crop in the United States is attacked by a large number of insects. The more important ones of widespread occurrence are aphids, wireworms, leafhoppers, the Colorado potato beetle, flea beetles, and grasshoppers. Those that cause important damage in limited areas only are the white-fringed beetles in the South and the potato psyllid in the high plains area. Blister beetles, plant bugs, stalk borers, and white grubs are generally distributed, but cause important losses only occasionally. Satisfactory control measures are available for most of these insects and are widely used. Losses have materially decreased since 1946 when DDT became available, but in 1953 DDT and parathion failed to control aphids and the Colorado potato beetle in some areas. During the period 1942-51 losses to potatoes from insect pests of all kinds averaged about 15 percent, amounting to $100,583,000 annually.

Losses to potatoes in Maine, prior to 1946, due to direct damage by four species of aphids were demonstrated in experimental plots by increases in yield of 20 to 73 percent in plots treated with rotenone or DDT as compared with plots not treated. When DDT came into general use in 1946, the average yield in Maine increased substantially. The per-acre yield for the period 1946-52 was 405 bushels as compared with 277 bushels for 1936-45. Therefore, in 1942-45 there appears to have been a loss of about 128 bushels per acre that has since been eliminated. Losses due to diseases transmitted by aphids have been discussed in Chapter IV.

Losses due to wireworms and other soil insects have also decreased because of new control measures, but current losses are considerable. Decreases in losses have been particularly outstanding in the irrigated lands, where DDT has been so effective in controlling the sugar-beet wireworm and the Pacific Coast wireworm. The eastern species of wireworms are not controlled by DDT, but chlordane has been widely used successfully, and heptachlor, dieldrin, and aldrin are giving promising results.

The potato leafhopper causes hopperburn, a disease found throughout the eastern part of the United States. Although DDT is very effective, the small inconspicuous leafhoppers may not be recognized, and hopperburn is often thought to be a result of hot, dry weather.

The potato crop in Colorado, Utah, Wyoming, western Nebraska, and Montana is subject to outbreaks of the potato psyllid, which is the cause of the disease psyllid yellows. The occurrence of outbreaks can now be predicted in time to warn growers of the necessity of applying control measures. An outbreak in 1949 caused the loss of about 7,849,000 bushels. This was the only outbreak during the period 1942-51, and surveys indicate that the average annual loss was 2,390,000 bushels.

Sweetpotatoes

The chief pest of sweetpotatoes is the sweetpotato weevil, which is partly a farm-storage problem. Although there is no satisfactory method for control during the growing season, weevil losses in the field are not appreciable at this time (except in Louisiana) because of quarantine and regulatory measures, farm and storage sanitation, and the use of DDT on the harvested crop. Losses from the weevil are now less than those from soil insects such as wireworms and flea beetle larvae.

The sweetpotato weevil occurs in commercial sweetpotato-producing areas in all Gulf Coast States, in Georgia, and in two counties of South Carolina. Infested potatoes are unfit for human consumption, and livestock refuse to eat those heavily infested. Losses to growers result from reduction of yield and costs of complying with State quarantine regulations. Packers and shippers experience losses in storage, increased packing costs, and the expense of sanitation treatments to prevent infestation in storage. In 1945, for example, a $1 million business was destroyed in Georgia as a result of infestation by this pest, and in 1952 losses to certified plant growers in Alabama and Mississippi amounted to about $30,000.

In 1946 losses in six major sweetpotato-producing parishes in Louisiana were estimated to be about $3,000,000. Through the efforts of the State and Federal governments, growers, and packers, they had been reduced to about $240,000 in 1951. The annual loss for the period 1946-51 was $1,740,000.

Tomatoes

Tomato seedlings are attacked by cutworms, flea beetles, and other general feeders. Older foliage is injured by various caterpillars, aphids, leaf miners, the Colorado potato beetle, spider mites, thrips, blister beetles, the potato psyllid, and the tomato russet mite. The fruits are damaged chiefly by the tomato fruitworm and the tomato pinworm. Aphids and the beet leafhopper transmit various virus diseases, losses by which were discussed in Chapter IV. Damage by the potato psyllid is confined chiefly to Utah and Colorado, where the annual loss during 1942-51 was about 4,500 tons, worth $129,000.

Damage by the tomato fruitworm and hornworm was reduced during this period by improved control measures and is estimated at approximately $6,660,000. The tomato pinworm, which had previously caused heavy losses, principally in California, caused little damage. Leaf miners, however, caused greatly increased damage in California, Texas, and Florida. The tomato russet mite became a new pest of tomatoes

throughout California, in parts of Arizona and Utah, and, since 1951, in a number of eastern States. The Colorado potato beetle spread along the Atlantic coast as a relatively new pest of tomatoes. Control measures are fairly satisfactory except for leaf miners. The total loss to tomatoes caused by insects is not known.

Ornamental Plants and Shade Trees
(Table 8)

Ornamental Plants

Insect control in greenhouses has attained a new level of efficiency since about 1946. Most pests that formerly seriously injured greenhouse crops are now controlled with the modern pesticides. In the colder parts of the country insects that do not survive outdoors have almost disappeared from greenhouses. Some of these are the carnation aphid, crescent-marked lily aphid, orchid thrips, orchid weevil, greenhouse thrips, Surinam roach, tomato pinworm, greenhouse leaf tier, soft scale, citrus mealybug, and Mexican mealybug. Those pests that survive outdoors continually reinfest greenhouses and cause some losses. Examples of this group are spider mites, the cyclamen mite, leaf rollers, cutworms, the onion thrips, garden centipede, rose aphid, green peach aphid, melon aphid, potato aphid, leafhoppers, spittle bugs, tarnished plant bug, rose scale, and leaf miners. The spider mites and the garden centipede have been particularly troublesome.

In 1930 the losses caused by insects and related pests to greenhouse flowers and ornamentals in Illinois were estimated to total about 15 percent (Ill. Nat. Hist. Survey, Ent. Ser. Cir. 12). This estimate was accepted for many years as typical of the greenhouse industry. During the past few years the losses have been in the neighborhood of 1 or 2 percent. In 1938 it was estimated that insect control cost about 5 cents per square foot. Although cost of production has more than doubled, the cost of controlling greenhouse pests has probably remained about the same.

An outstanding example of the reduction in losses to greenhouse crops is that to greenhouse roses due to spider mites and associated insects. Prior to 1946 the annual loss was estimated at approximately 10 percent, but since then it has been almost negligible. The annual loss for the period 1942-51 was about $1,647,000, or 5 percent. However, some strains of spider mites are already showing some resistance to the recommended control measures.

Shade Trees

In 1938 it was estimated that insect damage to shade trees plus the cost of controlling such insects amounted to $87,000,000 annually. For the period 1942-51 the losses, on the basis of a cost of $10 per tree for replacement alone, are roughly estimated

to have averaged about $75 million. Control costs are not included in this figure, but are included in the control estimates in Chapter XII.

CHAPTER VI. HAIL, IMPROPER CULTURAL OPERATIONS, WEEDS, RANGE PESTS AND DISEASES, AND FIRE

Crop production and pastures and ranges are subject to losses from hail, improper cultural operations, and other causes not covered in Chapters IV and V. Those losses are presented in Table 9. A further analysis of weed losses and costs is given in Table 10.

Crops

Hail Damage

Hail damage to growing crops is sporadic, and no precise statistics on which to base an estimate are available. The ratio of losses paid to the total amount of hail insurance carried on growing crops indicates that losses average about 1 percent of the value of all crops, being highest in the Plains area from Montana and North Dakota to New Mexico and Texas. Hail losses are low from Illinois to the East Coast, and west of the Rocky Mountains. Tobacco and fruit crops are highly vulnerable to hail, while forage crops sustain very little loss from this cause. Probably the only feasible means of reducing hail losses is by shortening the growing season. One reason farmers wish to harvest grain as early as possible is to avoid risk of hail damage.

Mechanical Damage

Mechanical damage to crops is due, directly or indirectly, to unsuitable types and improper use of machines.

Excessive pesticide application. When pesticides are applied either too irregularly or with too low concentration on the plant foliage, larger amounts must be used than with uniform and efficient application. The value of the material wasted is estimated at $30 million, which is over 10 percent of the cost of the pesticides used. Better design, adjustment, and operation of sprayers and dusters are required to avoid the loss.

Improper fertilizer placement. Seeds and seedling roots are injured by the soluble salts of fertilizer placed too near or otherwise in a hazardous manner. When the fertilizer is too widely scattered or too far away, the lack of early plant stimulation, the unavailability of part of the plant food, or weed stimulation and competition result in decreased yields. The damage varies widely with the innumerable circumstances. An estimated loss of $225 million is 1.5 percent of the total value of fertilized crops. Authoritative recommendations should be scrupulously followed to minimize hazards and attain effective use of fertilizers.

Improper planting. Planting seed either too deep or too shallow, insufficient compaction of the soil around the seed, moist surface

Table 9. Losses from Fire, Hail, Inefficient Farm Operations, and Weeds to Agricultural Crops, Pastures, and Ranges

Commodity and unit of production	Actual production 1/			Loss of production 2/			
	Quantity	Acreage	Value	Percentage	Quantity	Value	Acreage equivalent due to loss
	1,000 units	1,000 acres	1,000 dollars	Percent	1,000 units	1,000 dollars	1,000 acres
CROPS (58 crops)							
Hail		357,835	15,714,777	1.0		158,735	3,578
Mechanical damage		do	do	2.9		465,000	10,270
Weeds		do	do	10.2		1,789,175	36,576
TOTAL LOSS		357,835	15,714,777	-		2,412,910	50,424
PASTURES AND RANGES							
Diseases	-	(1,020,000)	(4,715,100)	8.2	-	419,427	83,130 5/
Fire effect on grazing	237,750 3/	(951,000)	475,500	0.1	330 3/	660 4/	1,318 5/
Grasshoppers	-	-	-	1.8	-	89,400	18,462 5/
Weeds and brush	-	1,020,000	4,715,100	9.1	-	471,510	92,727 5/
TOTAL LOSS	-	1,020,000	4,715,100	-	-	980,997	195,637 5/

1/ See footnote 1 of Table 1.
2/ See footnote 2 of Table 1.
3/ Represents number of animal units per month.
4/ Estimated at $2.00 per animal unit per month.
5/ Acreage equivalent of range land only.

soil pressed into a firm layer above the seed, improper elevation of the seed row with respect to the general level of the land, and other unfavorable planting conditions cause either delayed or low germination and an inferior stand of plants which is reflected in the crop yields. The adverse effects are manifest in many ways and are frequently severe enough to require replanting. Losses also result from faulty transplanting of seedlings and the use of excessive amounts of seed. The estimated $50 million loss is 5 percent of the total value of seed and seedlings planted. The loss may be prevented by selection of the most suitable planter or seeder, proper fitting of the seedbed, adjustment of the planting unit according to the circumstances, and planting at the proper time.

Root pruning. A plant suffers from lack of water and nutrition when too much of its root system is severed by tillage tools and furrow openers operated too deeply in the soil or too close to the plant. The location on the plant where the tools cause excessive pruning depends upon the kind of crop or nature of the root system, and the stage of plant growth or extent of root development. Hot weather and low soil moisture may aggravate these effects, which are reflected in the yield. The estimated loss of $60 million is about one-half of 1 percent of the value of cultivated crops. Unnecessary losses can be avoided by taking recommended precautions with regard to the operation of these tools.

Soil compaction. Excessive soil compaction by the wheels of tractors and heavy implements reduces air and water in the soil and otherwise makes conditions unfavorable for root development. The operation of a sprayer or duster a number of times in the same path compacts the soil so that yields of crops such as potatoes and cotton on the rows adjacent to the wheel tracks are reduced as much as 50 percent. With millions of acres of soil susceptible to excessive compaction, an estimated crop loss of $100 million from this cause seems conservative. Loosening the soil by the use of tillage tools mounted back of tractor wheels, lowering the unit-area pressure on the soil with wider tires, and the growth of deep-rooted crops are among the corrective measures.

Weeds

In his agricultural endeavors man has adjusted himself to live with certain species of plants growing where they are not desired. These plants are called weeds. Too often, and at prohibitive costs, weeds have been taken for granted. Unwanted, non-useful, often prolific and persistent, they reduce the efficiency of agricultural operations, increase labor, add to production costs, and reduce yields.

Weeds compete with crops for water, light, and mineral nutrients. For instance, one plant of common yellow mustard requires twice as much nitrogen, twice as much phosphoric acid, four times as much

Table 10. Losses Caused by Weeds 1/

Source of loss due to weeds	Acreage on which estimate is based	Percentage reduction in potential value of products	Value of products produced annually	Estimated Annual Loss in value
	Acres	Percent	Dollars	Dollars
Losses due to weeds in 58 crops (includes Field and Horticultural Crops)	357,835,000	10.2	15,714,777,000	1,789,175,000 2/
Losses due to weeds on pasture and grazing lands (includes pasture and grazing land in farms and non-farm grazing land) 3/	1,020,000,000	9.1	4,715,100,000	471,510,000
Losses involved in the cost of controlling weeds on agricultural land. (The cost of tillage is estimated at 16% of the value of the products produced. Approximately one-half of tillage is necessary due to weeds.)	977,520,000 4/	7.4	18,579,387,000 4/	1,486,351,000
Total losses due to weeds on agricultural land 5/	-	-	-	3,747,036,000

1/ Weed as defined in this estimate is any plant growing where it is not desired; including annual and perennial undesirable herbaceous plants, woody plants and brush, poisonous herbaceous and woody annuals and perennials, and any other plants encompassed in the definition of a weed.

2/ Estimated at $5.00 per acre.

3/ Losses include reduction in quantity and quality of livestock products such as dockage due to wild garlic flavor in milk.

4/ Acreage and product value cover cropland and pasture, but not range.

5/ This estimate does not include losses caused by weeds on such non-agricultural lands as railroad rights-of-way, along roadways, public utilities and around industrial and military installations, etc.

potash, and four times as much water as a well-developed oat plant. Common ragweed has a water requirement three times that of corn.

Weeds increase the cost of labor and equipment and impair the quality of farm products. Special equipment, such as tillage implements, mowers, sprayers, and burners, is required for weed control. Expensive seed-cleaning equipment in commercial seed houses is an additional cost made necessary by weeds.

During a 4-year period in Minnesota, North Dakota, South Dakota, and Montana the wheat crop contained 7 percent of dockage (largely weed seeds), or 360,000 tons annually. Flaxseed had an average annual dockage of 16 percent. At wheat prices of $2 per bushel, the farmers in these four States lost $24 million annually due to weeds after harvest alone.

Weeds harbor insect and fungus diseases that attack crop plants. Certain weedy mustards harbor the fungus that causes clubroot in cabbage. The fungus causing downy mildew of lettuce lives on prickly lettuce and sowthistle. These two weeds also harbor bean thrips.

Weeds also cause depreciation of land values and reduce farm loans.

The loss of $1,789,175,000 on cropland shown in Tables 9 and 10 is based on a reduction in value of the potential crop of $5 per acre, or about 10.2 percent. On pasture and grazing land the loss of $471,510,000 is slightly over 46 cents per acre. The cost of weed control on agricultural land has been estimated at $1,486,351,000, or 7.4 percent of the value of the crops. This estimate amounts to approximately $1.15 per acre. The total estimate of $3,747,036,000 does not include the cost of weed control on nonagricultural land, such as railroad, highway, utility rights-of-way, and industrial and military installations.

Pastures and Ranges

Diseases

The Great Plains. Many different grasses comprise the vegetation of the Great Plains. The predominant species are native short grasses, such as the gramas and buffalo grass. The wild-ryes and wheatgrasses are also common. Some of these species are susceptible to and sometimes heavily attacked by stem rusts, leaf rusts, and smuts. Powdery mildew sometimes occurs abundantly on the wheatgrasses of the northern Great Plains, and nearly all the species are attacked by leaf spot fungi. The greatest damage, however, probably results from root rots and seedling blights.

Northern Mountain-Intermountain region. Forage species of this region consist mainly of bromegrasses, fescues, wheatgrasses, and

bluegrass, as well as the associated legumes alsike clover, white clover, and sweetclovers. Rusts, smuts, and leaf spots are the principal agents damaging the grasses, while the legumes are attacked by root rots, crown rots, and virus diseases. Disease damage to the legumes is one of the principal causes of loss in this region.

Southwest arid region. Grazing in this region is mainly on desert shrubs and associated grasses such as blue grama, dropseeds, and lovegrasses. Because of the extremely low humidity diseases are of little consequence except where forage is grown under irrigation.

Pacific coast region. From southern California to northern Washington forage is produced on dry land as well as on irrigated pastures and range. Many grasses are utilized, of which species of Bromus, Stipa, Lolium, Festuca, Poa, Phleum, and Hordeum predominate. Several species of Trifolium, Medicago, Melilotus, and Lotus comprise the leguminous components. Because of increased moisture the grasses are attacked more severely by many of the same pathogens that occur in the Great Plains. The legumes are attacked by sclerotinia crown rot, fusarium root rots, rhizoctonia foliar blight, virus diseases, and various fungus leaf spots.

Southern States. In the South diseases attack the important forage grasses and legumes throughout the year. Dallis and Bermuda grasses are attacked less than some of the others. Crown rust, for example, limits the utilization of annual ryegrass for winter grazing. Tall fescue is usually severely damaged by Rhizoctonia solani during the humid summer. Sudan grass is susceptible to half a dozen serious diseases that can reduce yields one-third to one-half, and orchard grass is affected by rust and leaf spot. Crimson clover is damaged nearly every winter by sclerotinia crown rot, which also attacks and sometimes severely damages Ladino, white, and red clovers. The clovers are also damaged by virus diseases and fungus leaf spots. Stands of red clover are sometimes nearly eliminated by southern anthracnose. The root-knot nematode attacks annual lespedezas and other legumes.

North Central and Northeastern States. Grasses of this region include orchard, smoothbrome, timothy, Kentucky bluegrass, fescues, and redtop. Stagonospora leaf spot is common on orchard grass, and Helminthosporium, Rhynchosporium, and bacterial foliar diseases attack smooth brome. Timothy, redtop, and Kentucky bluegrass are damaged by stripe smut, and bluegrass is sometimes damaged by Helminthosporium leaf spot and root rot. Sclerotinia crown rot and virus diseases are becoming increasingly important on Ladino clover, while alfalfa is damaged by bacterial wilt, black stem, and leaf spots. Red clover and alsike are susceptible to root rots, and birdsfoot trefoil to rhizoctonia foliar blight during warm, humid periods. Sweetclovers, particularly in the Midwest, are attacked by black stem and by root rots.

Fire

Range fires burn over about 2 million acres of rangeland each year. Assuming an average grazing capacity of 6 acres per animal unit-month, the annual loss of forage destroyed by fire represents about 330,000 animal unit-months of grazing. Assuming an average value of $2 per animal unit-month, the forage thus lost by fire has a direct value of about $660,000 annually. (Table 9). These fire losses also disrupt ranch operations and thus cause additional losses. In many cases additional losses result from the more permanent damage to perennial range species and deterioration of site.

Grasshoppers

About 20 species of grasshoppers are especially destructive to rangeland in the West, where they consume large quantities of forage that would otherwise support valuable livestock. The overall loss on 845 million acres of Federal, State, and private rangeland in 17 western States has been estimated at approximately $89,400,000 annually. For losses to crops by grasshoppers, see Chapter V.

Undesirable Plants

Grazing values on approximately 240 million acres of rangeland have been severely reduced or eliminated by the invasion of undesirable trees and shrubs such as mesquite, juniper, sagebrush, and post oak. Assuming an average reduction of 50 percent in grazing capacity on these areas and 4 acres per animal unit-month, the annual loss in grazing capacity amounts to about 30 million animal unit-months. This represents a loss of about 12 percent of the total potential rangeland, and at an average rate of $2 per animal unit-month a loss in grazing values of about $60 million.

In many areas poisonous or noxious plants cause additional losses of livestock. The annual loss of animals in Colorado alone attributable to poisonous plants averages about $1 million. Losses from poisonous plants in the range country as a whole average about 4 percent of the animals grazed. The poisonous plant halogeton now occupies about 2 million acres in the Western States and is rapidly spreading. Much rangeland is no longer usable for grazing because of the hazards of halogeton poisoning of sheep and cattle, and ranch values in many areas have materially depreciated. Other unpalatable plants, such as St.-Johns-wort and the medusa wild-rye, likewise are rendering large range areas useless and bring about serious losses in livestock and ranch values. Losses to livestock from plant poisoning are discussed in Chapter X and are included in Tables 20 to 24.

CHAPTER VII. HARVESTING AND STORAGE

Harvesting Losses
(Table 11)

Cereals (Wheat, Oats, Barley, Rye, Rice)

Most losses to cereals are due to (1) shattering of grain onto the ground and breakage of straw when harvested too dry, (2) wind and insect damage, (3) improper adjustment and operation of harvesting machinery, and (4) poor growing conditions. Timely harvest combined with drying of grain by mechanical ventilation will help to eliminate much of the losses due to shattering and breakage of straw, and some of those caused by wind, hail, and insects. Cutter-bar losses can be minimized by proper reel adjustment, and other machine losses by correct cylinder speed, clearance between concaves, correct number of concaves, and proper air-blast adjustment.

Corn

Losses to corn are due largely to (1) ears dropping to the ground, (2) corn shelled off ears, (3) stalks broken down, (4) harvesting when corn is too dry, (5) wind and corn borer damage, (6) crushing of kernels when harvested with too high moisture, (7) poor growing conditions, and (8) obsolete machinery. These losses can be greatly reduced by earlier harvesting. This is practical if ventilation is used to dry the corn when harvested. Losses can be further reduced by the proper adjustment of snapping and husking rolls and gathering points.

Cotton, Lint and Seed

Cotton losses are due to (1) plant population and nonuniformity of planting, (2) cultural practices influencing ground contour and weed growth, (3) time and method of harvesting (percent of bolls open), (4) storm losses caused by harvest delay, (5) bolls dropped on ground, (6) bolls missed by harvester, (7) improper adjustment and operation of machine, and (8) improper defoliation resulting in stained fibers.

Hay (All)

Losses of hay include shattering of the leaves and lowering of grade when hay is rained on between cutting and the time it is put in the barn or in stacks. Shattering losses are heaviest with alfalfa and other legumes. Rain damage on the cut hay is greatest with the first crop and in the humid parts of the country. Methods of avoiding loss by wetting are mow drying or ensiling the cut grass instead of making it into hay. Leaf shattering may be reduced by cutting the hay early, picking it up before it has fully dried, complete drying in the mow or bale, and by use of 4- or 6-bar side-delivery rakes, which handle the hay more gently than 3-bar rakes.

Legume and Grass Seeds

Losses of legume and grass seeds include shattering of ripe seed before it is fully mature and mechanical damage due to rough handling by the combine cylinder, concaves, beaters, and fan, which results in low germination. Much of the lighter seed is blown over if the cleaner fan is not properly adjusted. Means of saving a larger part of the crop are (1) to harvest early before the seed begins to shatter and then to dry the seed mechanically, and (2) to adjust the machines to handle the seed gently and thus avoid mechanical injury and blower loss. Vacuum machines are often used to pick up shattered seed from the ground after combining. Such machines are usually custom-operated. The means of avoiding these losses is not yet well understood.

Potatoes

Losses of potatoes include those left in the field by the digger, some of them because they were severely cut and damaged. There is some loss due to freezing of potatoes temporarily piled in the field pending transportation to the storage house. Harvesting losses can be reduced by using large, improved diggers designed to avoid damaging the potatoes and by setting the machines to dig deeper to harvest the whole hill and to gather sufficient dirt to protect the potatoes as they go over the elevators and sorting belts.

Sorghum, Grain

Losses of sorghum are due chiefly to (1) breaking off of heads, (2) breaking of stalks, (3) shattering of grain, (4) incomplete threshing, (5) improper adjustment and operation of harvesting equipment, and (6) poor growing conditions. Early harvest will prevent most losses due to breaking of heads and stalks and shattering. This practice is feasible by the methods of drying grain sorghum now being developed. Machine losses can be minimized by proper reel adjustment, correct cylinder speed (20 to 25 percent of normal speed for wheat and oats), proper clearance between concaves, correct number of concaves, and proper air-blast adjustment.

Soybeans

Soybean losses are due to (1) shattering of seeds, (2) breaking down of plants, (3) improper adjustment and operation of harvesting machines, and (4) breaking of seed during threshing. Timely harvest and the use of mechanical drying equipment will help eliminate losses when seed is too dry. Machine losses can be minimized by proper reel adjustment, correct cylinder speed (50 percent of that for wheat and oats), correct clearance and number of concaves, and proper air-blast adjustment. The use of pick-up fingers on the cutter bar will help to salvage downed plants.

Table 11. Losses Due to Harvesting of Crops (shattering, etc.)

Commodity and unit of production	Actual production 1/			Loss of production 2/			
	Quantity	Acreage	Value	Percentage	Quantity	Value	Acreage equivalent due to loss
	1,000 units	1,000 acres	1,000 dollars	Percent	1,000 units	1,000 dollars	1,000 acres
Cereals (wheat, oats, rye, barley, rice) (bu.)	2,812,342	133,848	3,445,762	5.0	148,018	181,356	6,692
Corn (bu.)	3,036,380	88,024	4,146,062	4.0 3/	126,516	172,753	3,521
Cotton, lint (bales)	12,215	22,036	2,043,635	2.5 3/	313	52,401	551
Cotton, seed (tons)	4,955	(22,036)	(2,043,635)	2.5 3/	127	4/	4/
Hay, all (tons)	102,296	74,666	2,088,144	21.0	27,193	555,076	15,680
Maple syrup (gals.)	1,939	-	7,056	30.0	831	3,024	-
Potato (bu.)	411,007	2,318	551,789	7.0	30,936	41,533	162
Seeds of grasses (lbs.)	135,760	(856)	(14,476)	17.5	28,797	3,071	(150)
Seeds of legumes (lbs.)	254,249	(3,248)	79,017	30.0	108,964	33,864	(974)
Sorghum, grain (bu.)	137,263	7,347	160,414	15.0	24,223	28,308	1,102
Soybeans for beans (bu.)	219,596	11,114	511,620	5.0	11,558	26,927	556
TOTAL HARVESTING LOSSES	-	339,353	13,033,499	-	-	1,098,313	28,264

1/ See footnote 1 of Table 1.

2/ See footnote 2 of Table 1.

3/ Preventable losses only; total losses are about double these figures.

4/ Value and acreage equivalent of cottonseed harvested and losses are included in cotton lint.

Storage Losses Other Than From Insects
(Table 12)

Cereals (Wheat, Oats, Barley, Rye, Rice)

Most storage losses of these grains, aside from insect damage, are caused by mold and self-heating of the grain. The rate at which these conditions develop depends largely on the amount of moisture. Excess moisture may be due to the condition of the grain when harvested, inadequate drying before or during storage, or wetting by leakage through walls or roof or by ground moisture. Losses vary with the length of storage, atmospheric temperatures, and the percentage of broken kernels and foreign material present. For example, small grains can be safely stored in the northern areas with 1 to 4 percent higher moisture than in southern areas.

Losses due to rodents include leakage through mice and rat holes in bins, bags, or other containers and befouling of the grain as well as that actually consumed.

Corn

Much of the loss in stored corn is due to mold and heating, which is generally caused by high moisture and inadequate ventilation. Such loss depends on the length of the storage period, atmospheric temperatures, and, particularly with ear corn in cribbed storages, the atmospheric humidity. Shelled corn that is broken while moving into tight bin storage or ear corn cribbed with much husk, silk, and shelled corn will also deteriorate faster than sound, clean corn.

Losses from molds and heating are generally higher in years of "soft corn," that is, when corn is more generally stored with excessive moisture, than in years of normal maturity. Soft corn occurred in 1945, 1947, and 1952 in the midwestern Corn Belt, particularly in the more northerly sections.

Losses due to rodents include leakage of shelled corn through rat holes in buildings, bags, or other containers and contamination of the corn that is not actually consumed.

Hay (All)

Losses of hay stored in mows are caused by molds and heating due to excess moisture in the hay when stored or to leaky structures. Such heating sometimes results in spontaneous ignition, with loss of both hay and buildings. Some losses from shattering of leaves may be caused by the method of handling, particularly in extremely dry hay.

Losses of loose or baled hay stacked in the field are due to the same causes and also to weathering of the outside layers of the stack and wetting of the stack bottom by ground or surface moisture.

Table 12. Losses During Farm Storage (other than insect damage)

Commodity and unit of production		Production stores on farms 1/ 3/			Loss of production in storage 2/			
		Quantity	Acreage	Value	Percentage	Quantity	Value	Acreage equivalent due to loss
		1,000 units	1,000 acres	1,000 dollars	Percent	1,000 units	1,000 dollars	1,000 acres
Cereals (wheat, oats, barley, rye, rice)	(bu.)	1,821,382	81,686	1,992,579	4.5 4/	81,962 4/	89,666 4/	3,676 4/
Corn	(bu.)	2,053,378	59,527	2,802,861	6.0 4/	123,203 4/	168,172 4/	3,572 4/
Cotton lint (fire)	(bales)	12,215	22,036	1,737,995	0.25	31	4,345	55
Hay, all	(tons)	69,537	50,757	1,419,453	7.0	4,868	99,362	3,553
Potato (late and intermediate)	(bu.)	127,378	1,885	168,139	8.0	10,190	13,451	151
Rodents in stored grains 5/	(bu.)	3,874,760	(141,213)	(4,795,440)	1.0	40,685	(50,352)	(1,483)
Sorghum, grain	(bu.)	58,315	3,121	67,153	6.0	3,499	4,089	187
Sugar beets	(tons)	10,027	829	104,573	2.5	251	2,614	21
TOTAL FOR FARM STORAGE LOSSES		-	219,841	8,292,753	-	-	381,699	11,215

1/ So far as possible the basic data represent the averages for the period 1942-51 as estimated by the Crop Reporting Board of the Agricultural Marketing Service. Where data were not available, best approximations were used. Value shown is the quantity valued at average prices received by farmers. Equivalent acreage is the quantity divided by average yield per acre.

2/ Losses are expressed in equivalent farm quantities, values, and acreages. See footnote 2 of Table 1 and Chapter 3 of text for more detailed explanation of procedure.

3/ All figures are for January 1 stocks, except those shown for wheat, oats, barley, and rye, which are for October 1 stocks. The entire crops of cotton lint and sugar beets are included.

4/ Rodent losses are included in these stored grain estimates.

5/ Quantities, values and acreage equivalents are included in respective figures for corn and wheat, oats, barley, rye and rice.

Potatoes

Losses of stored potatoes are due to (1) cuts and bruises, occurring in harvesting and handling into storage, that are not properly healed during the early storage period, (2) shrinkage and sprouting, (3) freezing, and (4) disease. The number and roughness of handling operations affect the number of bruises and cuts, though mature potatoes are injured less than immature ones, and warm potatoes less than cold ones.

Proper regulation of storage temperature and relative humidity promotes healing of cuts and bruises, reduces shrinkage and sprouting losses during the holding period, and controls certain storage diseases. Such regulation is obtained by proper construction and insulation of the building and by controlled ventilation.

Sorghum, Grain

Damage from mold and heating constitute the principal losses, except those due to insects, occurring in storage. The main causes are excessive moisture when put into storage and wetting because of leaky bins, or emergency storage in piles on the ground. The grain sorghum stalk is still green when the seed is mature. Pieces of wet stalks mixed with the grain raise the moisture content above the safe storage level. Severe mold often develops when the grain contains excessive amounts of stalk fragments and cracked seed.

Soybeans

High moisture is responsible for most soybean storage losses. Either the soybeans are wet when stored or they become damp in bins with leaky roofs and walls or defective floors. Mold and heating occur under these conditions, causing losses in quality as well as quantity. Mold action usually results in a high acidity of the oil, which reduces its commercial value. Seeds broken in moving into storage are more susceptible to mold damage than sound seeds. Losses are estimated at 3 to 6 percent or about $6,000,000.

Storage Losses Due to Insects
(Table 13)

The losses of stored grains due to insects can be estimated easily because of the availability of production and storage figures on the various grain crops. There was some change in the losses during the 10-year period 1942-51. Support loans caused more grains to be held on the farm for the full storage season and thus increased losses. Commodity Credit Corporation holdings were high early and again at the end of the period, which also increased losses. On the other hand, new varieties, better storage facilities, and improved storage procedures tended to decrease losses.

Table 13. Losses Due to Insects in Stored Field Crops

Commodity and unit of production	Production stored on farms 1/			Loss of production in storage 2/			
	Quantity	Acreage	Value	Percentage	Quantity	Value	Acreage equivalent due to loss
	1,000 units	1,000 acres	1,000 dollars	Percent	1,000 units	1,000 dollars	1,000 acres
Barley (bu.)	226,014 3/	9,359	304,532	2.5	5,650	7,613	234
Beans, dry edible (Indian meal moth) (lbs.)	1,028,200 4/	993	70,617	1.8	18,508	1,271	18
Beans, dry edible (weevils) (lbs.)	192,200 5/	143	17,298	1.0	1,922	173	3
Corn (old crop stored July 1) (bu.)	969,646 6/	28,110	1,323,567	0.3	2,698	3,682	78
Corn (10-year average 1942-51, farm stored January 1) (bu.)	2,053,378 7/	59,527	2,802,861	2.4	49,249	67,225	1,428
Oats (bu.)	1,260,127 3/	42,766	990,275	0.01	158	124	5
Peanuts (lbs.)	192,198	230	19,989	7.0	13,454	1,399	16
Rice (bu.)	106,904 3/	2,006	282,441	1.0	1,069	2,824	20
Rye (bu.)	16,046 3/	3,127	27,694	1.2	201	346	39
Sorghum, grain (bu.)	83,024 3/	5,061	129,972	3.4	2,847	4,483	164
Tobacco (lbs.)	2,117,593	1,584	1,089,505	0.5	9,621	4,991	7
Wheat (1951 carryover) (bu.)	852,571 8/	67,842	1,802,335	5.0	42,629	90,117	3,392
Wheat (in 1952 trade channels) (bu.)	1,154,407 9/	69,831	2,424,851	0.8	9,342	19,745	574
Wheat (as of Oct. 1, 1952, new) (bu.)	513,218 10/	(30,018)	(1,077,073)	1.2	6,240	13,111	367
TOTAL LOSSES IN STORED FIELD CROPS	-	290,579	11,285,937	-	-	217,104	6,345

1/ See footnote 1 of Table 12.

2/ See footnote 2 of Table 12.

3/ 1952 crop harvested.

4/ United States excluding California.

5/ California only (beans only, excluding lima beans - no estimates for peas - storage off farms only - California stores no beans on farms.)

6/ Represents quantity in all storage, on and off farms on July 1, 1952. Much of each corn crop is subject to insect damage for 2 years.

7/ Represents the 1942-51 crop, farm stored as of January 1.

8/ Represents the quantity in all storage, on and off farms, on January 1, 1952.

9/ Represents the 1952 crop in trade channels only. (1952 crop sold.)

10/ Represents the 1952 crop in farm storage as of October 1, 1952.

These losses are due to a number of species. One group - the rice weevil, granary weevil, Angoumois grain moth, and lesser grain borer - attack sound kernels. A second group - the cadelle, Indian-meal moth, flat and rusty grain beetles, saw-toothed grain beetle, dermestids, and confused and red flour beetles - may consume the germ of grains. The feeding of these insects, and also of flour moths and grain beetles, on broken grain and dockage may cause local heating in grains, with consequent formation of moisture, which will cause surface crusting and spoilage.

Estimates were also made of losses of dry edible beans and peas due to attack by the bean weevils, cowpea weevil, and Indian-meal moth; of stored tobacco by the tobacco moth and cigarette beetle; of farmers' stock peanuts by a complex of stored-product insects; of dried fruits by several stored-product insects; and of fabrics by fabric insects. However, the losses to dried fruits and fabrics are not included in the tables.

Insufficient data are at hand for estimation of losses of buckwheat (a minor grain crop) or soybeans (rarely attacked by insects), seed crops, or shelled peanuts. No attempt has been made to estimate losses of dried or processed foods such as flour, cereals, corn meal, pepper, spices, cheese, dried milk, dry beans, or macaroni during processing, in trade channels, or in the hands of the consumer.

Beans, Dry Edible

The annual loss in dry edible beans is estimated at 20,430,000 pounds. Part of this loss occurs in California due to bean weevils, and part in other producing areas due to the Indian-meal moth.

Corn

Corn losses from storage insects amounted to 51,947,000 bushels in 1952. Over 42 million bushels of this loss was in corn produced in the Southern States, where the rice weevil attacks corn in the field before harvesting and continues its depredations through storage. In the northern Corn Belt there is practically no loss in the first storage season, since the corn is harvested late in the fall and stored in cribs, where it rapidly cools to outdoor temperatures or is artificially dried to a point where insect activity is inhibited. There was some loss in the 1951 crop carryover. The total estimated loss is the equivalent of one-tenth of all the corn produced in Illinois.

Fabrics

The loss in value of fabrics containing wool due to insects is $350 million annually. The injury is greater on carpets, rugs, and wearing apparel than on blankets, upholstering, and the stored wool itself. The public spends $39,530,000 annually to prevent or control this injury to fabrics.

Fruits, Dried

The loss in fruit stocks intended for drying in 1952 is estimated at 5,000 tons. It includes losses on apples, apricots, dates, figs, peaches, pears, prunes, and raisins.

Peanuts

Most of the loss in farmers' stock peanuts in 1952 was in the 1951 carryover, since there is not much loss to the new crop until the spring and summer following harvest. This loss is estimated at 13,454,000 pounds.

Rice

The loss in rough rice for 1952 is estimated at 1,069,000 bushels. This entire loss occurred in the first storage season, since practically all rough rice is milled in 6 to 9 months after harvest.

Small Grains, Other Than Wheat

The loss in oats in 1952 is estimated at 158,000 bushels, in barley at 5,650,000 bushels, and in rye at 201,000 bushels.

Sorghum, Grain

The loss in grain sorghum in 1952 is estimated at 2,847,000 bushels. Most of this crop is produced in Texas.

Tobacco

The losses in tobacco in 1952 were due to the carryover from 1951 or earlier of stocks that were being cured. The loss in flue-cured tobacco is estimated at 8,654,000 pounds, and in cigar types at 967,000 pounds. Only flue-cured, cigar, and imported oriental tobaccos are subject to severe losses from insect attack. Burley and Maryland tobaccos are not appreciably injured by insects in storage.

Wheat

Wheat losses in 1952 due to insect attack in storage are estimated at 58,211,000 bushels. Of this total 6,240,000 bushels were lost in wheat stored on the farm for the first season, 9,342,000 bushels in wheat in trade channels, and 42,629,000 bushels in wheat carried over from the 1951 crop. This total was equivalent to the production from 4,333,000 acres of wheat land, or more than all the wheat grown in Ohio. In value this loss amounted to $122,973,000.

Losses attributable to the commercial marketing and processing of farm crops are considered here, while those that occur after the foods reach the kitchen are covered in Chapter XII. Marketing and processing losses of livestock and poultry products are discussed in Chapter X.

Many tons of farm commodities are damaged or destroyed by diseases and other causes between the time they are harvested and the time they reach the dining table. These losses are shared by growers, shippers, storage and transportation companies, marketing agencies, processors, and consumers. In some cases entire crates or even carlots are lost. In others the damage makes it necessary to reduce the sale price or spend considerable money to recondition and repack the produce.

Losses in Marketing Crops

The best available data on losses after harvest were obtained by analysis of 117,613 inspection certificates that were issued on about 16 percent of the cars of fruits and vegetables unloaded at New York City between 1939 and 1942. Since these certificates were for all cars received by a group of produce dealers cooperating in the survey, they covered cars that were in good or satisfactory condition as well as those with serious damage and may be considered representative of the rail shipments received at New York City during that period. These certificates showed that there was an average loss of about 700 carloads of fruit and 2,300 carloads of vegetables each year in the New York market alone.

Losses in nutritive value also occur during marketing. Especially subject to loss is vitamin C. Vegetables and fruit may lose appreciable quantities of this vitamin if they are stored under adverse conditions such as at high temperatures or are bruised in handling. Such loss is particularly great if poor handling results in discard of outer portions of green-headed vegetables in which nutrients are more concentrated than in the inner portions.

Fruits (Table 14)

Apples. - About 20.9 percent of the apples shipped to market are destroyed during shipment, in the market, or in the home by decay caused largely by blue mold and bull's-eye rot, scald, and internal breakdown. Decay per car ranges from 0 to as high as 34 percent. These losses may be reduced by packing-house sanitation, careful handling and packing to avoid bruises, harvesting at optimum maturity, use of oil-treated fruit wraps to prevent scald, and marketing before there is danger of internal breakdown.

Apricots. - Brown rot, Rhizopus rot, and gray mold cause about 0.8 percent of this fruit to decay during shipment. Decay per car

Table 14. Losses Incurred During the Marketing of Fruit Crops

Commodity and unit marketed	Farm production marketed 1/			Losses of production in marketing 2/			
	Quantity	Acreage	Value	Percentage	Quantity	Value	Acreage equivalent due to loss
	1,000 units	1,000 acres	1,000 dollars	Percent	1,000 units	1,000 dollars	1,000 acres
Apples (bu.)	80,000	937	150,000	20.9	16,720	31,350	-
Apricots (tons)	40	13	6,000	0.8	3/	48	-
Avocados (tons)	20	14	7,000	2.2	3/	154	-
Cherries (tons)	40	32	10,000	2.4	1	240	-
Citrus juices (tons) of fruit)	2,000	268	100,000	1.0 4/	-	1,000	-
Dried fruit (insects) (tons)	475	372	80,000	1.0	5	800	-
Cranberries (sold fresh) (barrels)	300	10	6,000	12.0	41	818	-
Grapefruit (tons)	900	82	40,000	12.8	115	5,120	-
Grapes (tons)	500	140	50,000	9.0	45	4,500	-
Lemons (boxes)	8,000	39	30,000	7.8	624	2,340	-
Limes (boxes)	220	5	800	4.6	10	37	-
Oranges (tons)	2,700	334	160,000	15.3	413	24,480	-
Peaches (bu.)	35,000	345	100,000	5.8	2,030	5,800	-
Pears (bu.)	16,000	93	40,000	7.2	1,152	2,880	-
Plums, fresh (tons)	80	27	11,000	5.0	4	550	-
Prunes, fresh (tons)	550	170	40,000	6.1	34	2,440	-
Pomegrantes (tons)	3	2	140	0.7	3/	1	-
Strawberries (crates)	6,196	84	45,029	25.1	1,555	11,302	-
Tangerines (boxes)	3,500	19	7,500	16.2	567	1,215	-
TOTAL FOR FRUIT MARKETING LOSSES	-	2,985	883,469	-	-	96,525	326

1/ So far as possible the basic data represent the averages for the period 1942-51 as estimated by the Crop Reporting Board of the Agricultural Marketing Service. Where data were not available, best approximations were made. Value shown is the quantity valued at average prices received by farmers.

2/ Losses are expressed in equivalent farm quantities, value, and acreages. Equivalent acreage is total value lost divided by the value of the farm production per acre.

3/ Less than 500.

4/ No quantity loss available; estimated loss of 1 percent in value from deterioration in flavor.

ranges from 0 to 19 percent. Losses may be reduced by a proper disease-control program in the orchard and by careful handling and packing and adequate refrigeration.

Avocados. - About 2.2 percent of the avocados are destroyed by decay and internal breakdown during marketing and in the home. Losses may be reduced by careful handling and prompt marketing and utilization.

Cherries. - Decay, due mostly to Rhizopus rot, green mold, brown rot, and gray mold, causes a loss of about 2.4 percent during shipment. Decay per car ranges from 0 to 49 percent. Losses may be reduced by packing-house sanitation, careful handling and packing, and adequate refrigeration.

Cranberries. - About 12 percent of the cranberries are affected by decay. Much of this damage occurs while they are in the retail store and is passed on to the consumer. The price may be reduced if the decay is very noticeable. Keeping the berries refrigerated until ready to use will reduce decay considerably.

Grapefruit. - Blue mold and stem end rot cause decay in about 12.8 percent of grapefruits during shipment, in the market, and in the home. Decay per car ranges from 0 to 24 percent, being lowest in December and highest in July. Blue mold is most important in California and Texas fruit. Both diseases are equally important in Florida fruit. Losses may be reduced by packing-house sanitation, careful handling to avoid injuries, treating the fruit with borax or sodium orthophenylphenate, use of diphenyl-treated wraps or cartons, and refrigeration.

Grapes. - The 9 percent decay in grapes during shipment and marketing is due to gray mold and Rhizopus rot. Decay per car ranges from 0 to 74 percent. Losses may be reduced by fumigating with sulfur dioxide in storage and in the cars and by refrigeration.

Lemons. - About 7.8 percent decay in lemons is caused during marketing and at home by blue mold, brown rot, and alternaria rot. Losses may be reduced by refrigeration and by marketing and using the fruit before it has been stored too long.

Limes. - About 4.6 percent decay, caused mostly by blue mold, occurs during marketing. Losses may be reduced by refrigeration.

Oranges. - Decay, caused mostly by blue mold and stem end rot, destroys about 15.3 percent during shipment, in the market, and in the home. Decay per car ranges from 0 to 14 percent. No stem end rot occurs on California oranges. Blue mold and stem end rot are equally important on Florida oranges. Losses may be reduced by packing-house sanitation, careful handling and packing to avoid injuries, treating the fruit with borax or sodium orthophenylphenate, use of diphenyl-treated fruit wraps and cartons, and refrigeration.

Peaches. - Decay, mostly from brown rot and Rhizopus rot, causes about 5.8 percent damage during shipment and in the market. Decay per car ranges from 0 to 69 percent. Losses may be reduced by using an adequate spray program in the orchard, by packing-house sanitation, and by adequate refrigeration.

Pears. - About 7.2 percent become decayed during shipment and in the market. The decay is caused mostly by blue mold and gray mold. Decay per car ranges from 0 to 39 percent. Losses may be reduced by careful handling and packing to avoid injuries, by use of copper-oil-treated fruit wraps, and by refrigeration.

Plums and Prunes. - Decay, mostly from blue mold and Rhizopus rot, causes a loss of 5 to 6.1 percent during shipment and in the market. Decay per car ranges from 0 to 59 percent. Losses may be reduced by careful handling to avoid injuries and by refrigeration.

Pomegranates. - Gray mold and blue mold cause about 0.7 percent decay during shipment. Decay per car ranges from 0 to 24 percent. Losses may be reduced by refrigeration.

Strawberries. - Decay, due mostly to gray mold and Rhizopus rot, causes about 25 percent loss during shipment, in the market, and in the home. The affected fruit is destroyed and the sales value of the package is greatly reduced. Decay per car ranges from 0 to 34 percent. Losses may be reduced by shipping only good-quality berries, prompt and adequate refrigeration following harvest, and prompt marketing and utilization.

Tangerines. - Blue mold and stem end rot cause a loss of about 16.2 percent during shipment, in the market, and in the home. Decay per car ranges from about 0 to 24 percent. Losses may be reduced by careful picking and packing to avoid injuries and by refrigeration.

Vegetables (Table 15)

Artichokes (Globe). - Most of the globe artichokes are grown in California. Inspection of 23 percent of the shipments to New York during the period 1935-42 showed that 6.4 percent were affected with decay caused mostly by gray mold. Decay per car ranged from 0 to 54 percent. Decay was most prevalent during the first 5 months of the year. Affected artichokes are destroyed, and the market value of the package is reduced. Decay may be controlled by careful harvesting and packaging and by refrigeration during shipment.

Asparagus. - About 2.8 percent of the asparagus shipped from California to New York during the period 1935-42 showed decay on arrival. Most of the decay was caused by bacterial soft rot, but some was caused by phytophthora rot and blue mold. Decay per car ranged from 0 to 44 percent. Decay may be reduced by discarding bruised and cut shoots when packing and by refrigeration.

Table 15. Losses Incurred During the Marketing of Vegetable Crops

Commodity and unit marketed		Farm production marketed 1/			Losses of production in marketing 2/			
		Quantity	Acreage	Value	Percentage	Quantity	Value	Acreage equivalent due to loss
		1,000 units	1,000 acres	1,000 dollars	Percent	1,000 units	1,000 dollars	1,000 acres
Artichokes	(boxes)	726	7	2,268	6.4	46	145	3/
Asparagus	(tons)	66	51	14,498	2.8	2	406	1
Snap beans	(bu.)	17,951	184	43,616	8.0	1,436	3,489	15
Lima beans	(bu.)	1,831	26	4,662	12.6	231	587	3
Beets	(bu.)	2,136	12	2,030	1.2	26	24	3/
Broccoli	(crates)	3,845	36	15,112	9.6	369	1,451	3
Brussels sprouts	(tons)	25	6	4,992	1.5		75	3/
Cabbage	(tons)	1,029	135	52,556	11.6	119	6,096	16
Carrots	(tons)	728	74	52,634	4.2	31	2,221	3
Cauliflower	(crates)	11,531	33	15,045	11.7	1,349	1,760	4
Celery	(tons)	703	37	53,470	18.6	131	9,945	7
Cucumbers	(bu.)	5,518	46	12,096	2.0	110	242	1
Eggplant	(bu.)	1,308	6	1,979	5.0	65	99	3/
Escarole	(tons)	22	5	2,419	8.4	2	203	3/
Lettuce	(tons)	1,262	205	122,456	24.5	309	30,002	50
Cantaloupes and muskmelons	(tons)	483	123	43,089	13.2	64	5,688	16
Honeyballs and mixed melons	(tons)	1		144	4.3		6	3/
Honeydew melons	(crates)	3,293	12	5,982	2.2	72	132	3/
Onions	(50 lb. sacks)	36,505	135	48,552	26.0	9,491	12,624	35
Peas (fresh)	(bu.)	5,113	58	10,070	4.7	240	473	3
Peppers	(tons)	111	37	18,755	25.3	28	4,745	9
Peanuts 4/ rejections at selling points	(lbs.)	810,178	2,951	197,074	9.6	170,137	18,919	283
Potatoes	(bu.)	324,053	2,318	430,201	15.5	50,228	66,681	359
Spinach	(bu.)	10,641	44	11,719	7.3	777	855	3
Sweetpotatoes	(bu.)	24,191	591	48,134	18.8	4,548	9,049	111

Tomatoes	(bu.)	34,408	228	119,676	21.6	7,432	25,850	49
Watermelons	(melons)	84,736	330	28,318	15.0	12,695	4,248	50
TOTALS		-	7,690	1,361,547	-	-	206,015	1,021

1/ See footnote 1 of Table 14.

2/ See footnote 2 of Table 14.

3/ Less than 500 acres.

4/ Listed elsewhere as a field crop. Peanuts are the only field crop on which the committee has made marketing loss estimates.

Beans, Lima. - Lima beans may be affected by gray mold, bacterial soft rot, watery soft rot, bacterial blight, and other diseases during shipment and marketing. Some of these diseases destroy the pods and beans. Others make them so unattractive that their market value is reduced. Losses may be reduced by not packing beans from badly affected crops, by careful grading, by adequate refrigeration, and by prompt marketing.

Beans, Snap. - About 8 percent of the snap beans shipped to market are lost during transit, marketing, or in the hands of the consumer because of decay caused by Sclerotinia and Rhizoctonia, or their salability is reduced by pod spots caused by bacterial blight or anthracnose. In some cars 44 percent of the beans were affected. Losses may be reduced by not packing beans from badly diseased fields, by adequate refrigeration, and by prompt handling and utilization.

Beets. - Most of the damage to beets is due to bacterial soft rot and gray mold rot of the leaves of bunched beets. This does not affect the edibility of the root, but does seriously detract from the market value. About 91 percent of the shipments are free of decay, but as much as 79 percent of the beets in some cars may be affected. Losses may be reduced by prompt handling and adequate refrigeration.

Broccoli. - Decay due mostly to bacterial soft rot and leaf spot causes about 9.6 percent loss during shipment and in the retail store. Some of the affected bunches are a complete loss and the salability of the package is reduced. Decay per car ranges from 0 to 94 percent, but 90 percent of the cars are free of decay. Most of the losses occur in the shipments made from January through March. They may be reduced by adequate refrigeration during shipment and at the market.

Brussels Sprouts. - Bacterial soft rot causes about 1.5 percent loss during shipment and probably additional losses during marketing. It is found in about 40 percent of the cars shipped, and in some cars the damage may be as high as 39 percent. Losses may be reduced by packing only good-quality brussels sprouts and by refrigeration.

Cabbage. - Bacterial soft rot, watery soft rot, alternaria leaf spot, black rot, and gray mold cause a loss of about 11.6 percent during shipment and marketing. Some of the cabbage heads are completely destroyed, and others are made so unattractive that their market value is greatly reduced. Losses may be reduced by packing only good-quality cabbage and by refrigeration.

Carrots. - Bacterial soft rot, watery soft rot, gray mold, Rhizopus rot, and fusarium rot cause about 4.2 percent loss during shipment and marketing. Bacterial soft rot affects the tops of bunched carrots as well as the roots. The other diseases occur mostly on the roots. Losses may be reduced by packing only good-quality carrots and by refrigeration.

Cauliflower. - Losses during shipment, marketing, and in the home amount to about 11.7 percent. These losses are caused mostly by bacterial soft rot, watery soft rot, and alternaria rot of the curd. Bacterial soft rot may affect both the leaves and the curd. Cauliflower in about 15 percent of the shipments is affected, and the decay may amount to as much as 54 percent. Losses may be reduced by packing only good-quality cauliflower and by adequate refrigeration.

Celery. - About 18.6 percent of the celery is damaged during shipment, marketing, and in the home. Most of the loss is caused by watery soft rot, bacterial soft rot, and blackheart (physiological). These diseases rapidly destroy the celery bunches and make them unfit for food. About 60 percent of the shipments contain from a trace to 99 percent of decay. Losses may be reduced by packing only good-quality celery, by hydrocooling before shipment, and by adequate refrigeration.

Cucumbers. - About 2 percent of the cucumbers are damaged during shipment by bacterial soft rot, cottony leak, and watery soft rot. The cucumbers in over half of the cars are affected, and the decay per car ranges from a trace to about 24 percent. Losses may be reduced by packing only good-quality cucumbers and by refrigeration.

Eggplant. - Fruit rot causes about 5 percent loss in the market and in the home. Moderate refrigeration (about 45° to 50° F.) will retard development of this disease.

Escarole. - Decay, due mostly to bacterial and watery soft rot, causes about 8.4 percent loss in shipments of escarole. It occurs in more than half the cars shipped and ranges from a trace to 84 percent. Adequate refrigeration will reduce these losses.

Lettuce. - Tipburn (physiological) and bacterial soft rot cause a loss of about 24.5 percent during shipment, in the market, and in the home. About two-thirds of the shipments are affected, and the decay per car ranges from a trace to 99 percent. Sometimes the affected lettuce can be salvaged by trimming away the outer leaves, but tipburn usually occurs throughout the head, so that the affected lettuce is a complete loss. Losses may be reduced by not shipping lettuce from fields in which tipburn is causing serious damage, by careful trimming and packing, and by adequate refrigeration.

Muskmelons. - Decay causes a loss of 13.2 percent during shipment, marketing, and in the home. Decay is found in about half the shipments. Losses may be reduced by packing only good-quality cantaloups, by refrigeration, and by prompt marketing and utilization.

Melons, Honeydew and Honeyball. - Decay causes a loss of 2.2 to 4.3 percent during shipment, and is found in about 40 percent of the shipments. Losses may be reduced by packing only good-quality

melons and by adequate refrigeration.

Onions. - Bacterial soft rot, gray mold, black rot, and smudge cause about 20 percent loss during shipment, marketing, and in the home, and freezing and sprouting cause about 6 percent loss. Decay is found in three-fourths of the cars shipped and amounts to as much as 89 percent in some of them. Losses may be reduced by shipping only good-quality onions, by refrigeration, and by prompt marketing and utilization.

Peas (Fresh). - About 4.7 percent of the peas shipped to market are damaged by bacterial or watery soft rot and other decays. Decay per car ranges from 0 to 84 percent. Losses may be reduced by shipping only fresh good-quality peas, by prompt and adequate refrigeration, and by prompt marketing.

Peppers. - Rhizopus rot, bacterial soft rot, gray mold, anthracnose, scald, and freezing damage about 25.3 percent of the peppers during shipment, in the market, and in the home. About 60 percent of the shipments are affected. Decay per car ranges from 0 to 94 percent. Losses can be reduced by shipping only good-quality peppers and by adequate refrigeration.

Potatoes. - Decay, caused mostly by bacterial soft rot, blackheart (physiological), and freezing, damages 15.5 percent of the potatoes during shipment, in the market, and in the home. Decay per car ranges from 0 to 64 percent. Losses may be reduced by shipping only good-quality potatoes, by proper refrigeration or protection from cold during shipment, and by careful handling to avoid injuries.

Spinach. - About 7.3 percent of the spinach is damaged by bacterial soft rots, downy mildew, or white rust during shipment. About 40 percent of the cars are affected with decay, which ranges from a trace to about 94 percent. Losses may be reduced by shipping only good-quality spinach and by adequate refrigeration.

Sweetpotatoes. - Decay, caused mostly by Rhizopus, black, and fusarium rot, destroys about 18.8 percent during shipment, in the market, and in the home. It is found in 42 percent of the shipments. Losses may be reduced by not packing sweetpotatoes from lots known to be affected by rot, by proper curing to heal cuts and bruises, by careful handling to avoid new injuries, by avoiding chilling temperatures, and by prompt marketing and utilization.

Tomatoes. - About 21.6 percent of the tomatoes are damaged by bacterial soft rot, Rhizopus rot, alternaria rot, Phoma rot, late blight, and other decays and by freezing and chilling. Decay is found in about 80 percent of the shipments, and ranges from a trace to 84 percent per car. Losses may be reduced by packing only good-quality tomatoes, by careful packing and handling, and by shipping and ripening at suitable temperatures.

Watermelons. - About 15 percent of the watermelons are damaged by anthracnose, stem end rot, and other decays before they reach the consumer. Losses may be reduced by not shipping melons from fields in which anthracnose is causing serious damage, by treating the freshly cut stems with bordeaux paste after the melons have been loaded in the cars, and by careful handling and loading to avoid injury.

Losses in Processing Farm Crops

In addition to the many losses to crops and livestock at the farm level and those incurred in transportation and handling of the unprocessed material, important losses are incurred during preprocessing and processing procedures. Many of these losses could be avoided, but some only at prohibitive costs. Certain products are improperly handled prior to leaving the farm, and in such cases preventive or corrective measures during processing are of little avail.

The distinction between avoidable and unavoidable losses is not always well defined. The removal of fruit and vegetable peel or rind prior to canning, freezing, or dehydration is an example of the difficulty of making such a determination. Orange rind is used as cattle feed; therefore, rind that is not recovered would be a loss of a byproduct. Peels and pits of some other fruits are not acceptable for feed, and when removed do not constitute a loss in themselves. However, appreciable amounts of the fruit or vegetable pulp may be removed with the peel and would be considered a loss. In the process of juice extraction there are losses due to spillage and failure to recover the juice from the rag and peel. It has not always been possible to recover and use these edible juices economically, and frequently where such juices are recovered it has been done in order to avoid stream contamination.

Another loss is the reduction in nutritive value. The loss of carotene in the harvesting, drying (field or rotary), and storage of alfalfa is an example. This loss is avoidable since methods to reduce it are available.

The discarding or unwise use of materials known as agricultural residues has not been included among the losses covered in this report. Among such materials are wheat and other grain straws, corn stover and cobs, stems and pods of soybeans, cotton stalks, and sugarcane bagasse. Uses for nutshells have been suggested. One use is returning them to the soil, and frequently they are used as fuel. Cottonseed hulls and rice hulls are also frequently used as fuel. Oat hulls are used for the production of chemicals, and possibly such a use could apply to cottonseed and rice hulls, so that their use for fuel might not be the best use for national welfare.

The loss percentages on fruits and vegetables in Tables 17 and 18 relate only to the loss of edible materials, materials that might have been used as human food. Even though discarded edible material is used for some other purpose, such as animal feeds, fertilizers, or industrial products, it is nevertheless considered a loss.

Field Crops (Table 16)

Corn Oil. - The total production of corn oil in 1950 was 123,927 tons with a value of $39,656,000. Some of this oil came from the 70 million bushels of corn that was dry-milled that year, by which method only 0.6 pound of oil is recovered from a bushel of corn. If the methods used by the wet-milling industry were employed in all plants, 35,000 additional tons, worth $11,200,000, would have been produced. However, since the oil remaining in the corn goes into byproduct feed, it increases the value of the feed by $2,625,000, leaving a net loss of $8,575,000 from inefficient milling.

Cottonseed. - About 4,338,000 tons of cottonseed, worth $268,434,000, were crushed annually during 1942-51. The hydraulic and screw pressing processes, which predominate, have been leaving 128,200 tons of crude oil in the residual cake. Further losses occur through the use of inefficient methods of refining and further processing.

Investigations have indicated that, with proper adjustment of processing conditions, the feeding value of the entire output of cottonseed meals could be raised as much as 20 percent. The most important losses are the impairment of the nutritive value of the protein and the reduction of the free gossypol content to a minimum to permit unrestricted feeding to nonruminant animals, primarily swine and poultry.

Maple Sirup. - Failure to remove clouds (sugar sand) from sirup causes it to be down-graded. The lowering of one grade decreases the price by 50 cents per gallon. The loss to the farmer from this cause can be corrected by filtration of the sirup. Present farm equipment does not usually give a product of the desired clarity. Commercial equipment is not feasible because of cost. Development of efficient equipment and procedures through research should prevent these clouds.

Peanuts. - The peanut oil estimates cover the loss in refining due to free fatty acids and gums. The loss is in the form of soap stock, or foots, since soap stock is of lower value than oil. Deterioration during curing and storage may increase the free fatty acid content and thus increase refining losses.

Rice. - Losses in rice milling arise from broken grains, which must be sold at lower prices than whole-grain rice.

Soybeans. - The processing of 7,549,000 tons of soybeans in 1950 yielded 1,037,000 tons of crude oil, equivalent to 13.7 percent of the weight of the beans. 44 percent of the beans were processed mechanically. If solvent recovery had been employed on this portion, 1.75 additional pounds of oil could have been recovered per bushel, or 96,000 tons of oil worth $26,950,000. There would have been a decreased weight of meal amounting to 96,000 tons; at $75 per ton this would have been worth $7,200,000. A maximum increased net return of $19,750,000 might have been possible.

Sugar Beets. - Beets grown for sugar are subject to losses during storage and processing in the mills through respiration of the living beet tissue, destruction of the tissue by micro-organisms, molasses formation, inclusion of sugars in wash waters, and incomplete extraction from pulp. Losses can be reduced by proper temperature control in the diffusion batteries to minimize conversion to lactic acid.

Sugar Cane. - Over 6 million tons of cane are processed annually in this country. Losses arise from the presence of trash and dirt, sugar inversion and loss of weight between harvest and milling, sugar left in the bagasse during extraction, and inability to extract some of the sugars by crystallization from the blackstrap molasses.

Tobacco, Cigarette. - Losses in cigarette tobacco include decreases in grade and value due to improper curing. Development of improved firing equipment and methods, as well as temperature and humidity controls, should be a feasible solution to the problem.

Tobacco, Cigar. - Losses in cigar tobacco result from disintegration and decay of the cured leaf either in the sheds or when packed in cases or hogsheads, because of inadequate moisture control. Development of methods for accurate moisture measurement and control should eliminate this loss. Every 3 to 4 years certain tobaccos lose value because they do not ferment properly. The use of catalysts and additives to stimulate the enzymatic and bacterial fermentation processes should provide a remedy.

Tung Oil. - Tung fruit is hulled as a preliminary step to further processing in the production of oil. Tung hulls accumulate and present a disposal problem. Only limited use has been established for these hulls. Their bulk is a deterrent to their shipment to centers where they might be used. Also, chemical constituents, such as potash or tannins, can be obtained to better advantage from other sources.

Oil is lost both in the hulling and in the expression of oil from the hulled fruit. Broken kernels, which are the source of oil, and oil released from the kernels on breaking are carried along with the hulls as they are removed from the fruit. Furthermore, in the milling operation oil is either polymerized or retained in the press

Table 16. Losses in Processing of Field Crops or Products

Commodity	Farm production processed 1/		Losses of production in processing 2/			
				Loss in Value		
	Quantity	Value	Quantity lost	Amount	Percentage of value	Acreage equivalent due to loss
	1,000 tons	1,000 dollars	1,000 tons	1,000 dollars	Percent	1,000 acres
Corn oil - extraction	124 3/ 4/	39,656 4/	35 3/	(11,200)	-	-
Less salvage	-	-	-	(2,625)	-	-
Net loss	-	-	-	8,575	17.8 4/	182
Cottonseed oil, crude - net loss in extraction	686 4/	4/	128	40,177	15.7 4/	5/
Cottonseed oil, refined	(625) 4/	222,476 4/	52	16,801	7.7 4/	5/
Cottonseed oil, further processed	(609) 4/	4/	16	5,569	2.5 4/	5/
Cottonseed cake and meal loss in protein	1,964 4/	125,225 4/	none	24,922	16.7 4/	5/
Peanut oil, refining	67	20,875	4	1,252	6.0	16
Maple sirup, processing	11	7,056	6/	236	3.4	-
Rice, broken grains	1,756 4/	160,922 4/	none	15,900	9.0 4/	158
Soybean oil-extraction	1,037 4/	290,239 4/	96	(26,950)		
Less salvage				(7,200)		
Net loss				19,750	6.37 4/	429
Sugar beets - processing	10,027 7/	104,573	37 7/	375	0.36	3
Sugarcane processing	6,281 8/	37,407	1,633 8/	9,741	26.0	82
Tobacco - curing and storage decays	974	881,868	17	15,432	1.75	29
Cigars	66	65,660	1	1,313	2.0	2
Tung oil - extraction	20	11,088	3	1,342	12.1	30
TOTALS FOR FIELD PROCESSING	23,013	1,967,045	2,022	161,385	-	931

1/ See footnote 1 of Table 14. Figures in parentheses are included in other figures in the Table, and accordingly are not added into the column totals.

2/ See footnote 2 of Table 14.

3/ Represents the quantity of oil produced and quantity of oil lost, respectively.

4/ In these cases, the quantities and processing values represent the net amounts after the loss occurred; the percentage of loss is based on the potential crop and the value that would have been produced had the loss not occurred. In all other items in this table and all items in Tables 17 and 18 the quantity and processing values represent the gross amounts before the raw material enters the processing plant and the percentage of loss is based on the actual quantity and processing value of the harvested crop entering the processing plant.

5/ The production values of crude and further processed cottonseed oil are included in the figures for refined cottonseed oil. No acreage equivalents of the loss values are given, since seed is only a byproduct of lint production. However, the values indicate that the seed needed for the quantities of oil, cake, and meat actually produced could have been raised on 947,000 fewer acres if these causes of loss had been eliminated.

6/ Less than 500 tons (about 360 tons or 65,000 gallons).

7/ Represents the quantity of beets produced. The losses are given in beet equivalent.

8/ Represents the quantity of cane produced. The losses are given in cane equivalent.

cake, and therefore must be considered lost. While there is general agreement as to the losses in the hulling operation, the efficiency of the pressing operation has not been definitely established. The tabulated loss estimates are based on the 1952 crop rather than on an average of 1942-51. This crop was the first one in several years to reflect the production from the present number of tung trees, since freezes in the two preceding seasons cut production.

Fruit Crops (Table 17)

Adequate and accurate data are not available on losses occurring in the processing of fruits. For example, companies can give figures on yield of cases of canned fruit, per ton of incoming fruit, but not on losses in preparation and subsequent handling. The number of cases per ton is not adequate for several reasons: (1) The edible loss is not known and calculated losses include inedible portions; (2) leaching losses occur, replacing nutritive solids by water, sirup, or brine; and (3) cans are filled with both fruit and sirup, the fruit varying by size and grade and the sirup varying in density.

Only loss of edible material has been estimated. For example, in the production of orange juice there is a loss of skin and seeds and inedible and edible juice which cannot be or is not extracted by available methods. The unextracted juice, later utilized in cattle feed, is considered as a food loss.

Edible losses occur in several places along the processing line:

Preparation losses result from excessive peeling and trimming; flesh removal when a fruit is pitted; juices lost through handling; removal of culls, moldy fruit, and otherwise undesirable material; and removal of outside protective leaves. Not considered as edible losses are peel, stems, caps, pits, and seeds.

Leaching is always a problem with cut material. Leaching losses can only be guessed because of inadequate data and variable processing conditions throughout the country. When water blanching and/or fluming are employed, losses are high. Nominal allowances for leaching losses are included in the tables.

Respiratory losses may occur in any fruit held before processing. Pears are particularly susceptible, as they are picked green and allowed to ripen. Dried fruits held in sweat boxes until packaging also lose weight. Respiratory and other storage losses are included in the tables.

Vegetable Crops (Table 18)

Many of the comments relating to fruit-processing losses are equally applicable to vegetables. The estimates cover the destruc-

Table 17. Losses in Processing of Fruit Crops and Products

Commodity	Farm production processed 1/		Losses of production in processing 2/			
	Quantity	Value	Quantity lost	Loss in Value: Amount	Loss in Value: Percentage of value	Acreage equivalent due to loss
	1,000 tons	1,000 dollars	1,000 tons	1,000 dollars	Percent	1,000 acres
Apples	800	29,300	224	8,200	28.0	123
Apricots	179	15,740	34	2,990	19.0	11
Blackberries, raspberries, etc.	45	13,500	11	3,375	25.0	15
Cherries	136	26,656	15	2,932	11.0	12
Cranberries	16	228	2	34	15.0	2
Figs, dried	96	7,008	29	2,117	30.0	8
Figs, canned	11	1,254	1	125	10.0	3/
Grapes, dried for raisins, fresh basis	1,060	48,230	265	12,058	25.0	62
Grapes, canned	20	1,240	2	124	10.0	1
Grapefruit	1,030	25,750	113	2,833	11.0	10
Lemons	154	3,696	19	454	12.3	3
Olives	47	9,045	3	634	7.0	2
Oranges	1,570	62,800	188	7,520	12.0	35
Peaches	633	37,347	177	10,400	28.0	74
Pears	283	21,400	99	7,500	35.0	24
Plums and fresh prunes, canned and frozen	34	1,700	2	100	6.0	1
Prunes, dried	536	40,200	107	8,040	20.0	25
Strawberries	42	14,280	6	2,142	15.0	3
TOTALS FOR FRUIT CROPS PROCESSING	6,692	359,374	1,297	71,578	-	411

1/ See footnote 1 of Table 14.

2/ See footnote 2 of Table 14.

3/ Less than 500 acres.

Table 18. Losses in Processing of Vegetable Crops

Commodity	Farm Production Processed 1/		Losses of Production in Processing 2/			
	Quantity	Value	Quantity Lost	Loss in Value: Amount	Loss in Value: Percentage of Value	Acreage Equivalent due to loss
	1,000 tons	1,000 dollars	1,000 tons	1,000 dollars	Percent	1,000 acres
Beans, dry edible	169	25,688	8	1,280	5.0	17
Beans, lima green	58	7,520	9	1,128	15.0	12
Beans, snap green	232	24,244	23	2,424	10.0	13
Beets, canned	142	2,844	14	284	10.0	2
Broccoli	15	1,950	3	390	20.0	1
Brussels sprouts	8	1,550	2	496	32.0	1
Cabbage, kraut	176	2,430	9	122	5.0	1
Carrots, topped	85	2,120	17	424	20.0	2
Cauliflower	18	1,195	4	239	20.0	1
Corn, sweet, canned and frozen	1,181	23,131	331	6,490	28.0	130
Cucumbers, for pickles	219	12,142	22	1,214	10.0	12
Peas, green, canned and frozen	432	36,035	86	7,200	20.0	86
Potatoes, processing 3/	775	15,500	78	1,550	10.0	15
Spinach	116	5,450	34	1,745	30.0	12
Sweetpotatoes	261	19,750	65	4,938	25.0	25
Tomatoes	2,993	81,334	300	8,133	10.0	46
TOTALS FOR VEGETABLE CROPS PROCESSING	6,880	262,883	1,005	38,057	-	376

1/ See footnote 1 of Table 14.

2/ See footnote 2 of Table 14.

3/ The potato figures include the quantities used for chips, dehydration, canning, potato flour, and frozen French-fried, but omit the potatoes used for alcohol and starch production.

tion of edible material during preparation, leaching losses, and respiratory losses. Pea and lima bean pods, corn husks, and corn cobs are not considered edible and their removal was not included in the estimates.

Losses of Forest Resources

The mortality of standing timber in United States forests resulting from natural causes is estimated at about 2.15 billion cubic feet annually. In terms of sawtimber (Table 19), annual mortality from all natural causes totals about 8.7 billion board feet. These losses represent about 0.5 percent of the total stand of timber and about 15 percent of the current annual growth of timber crops. These losses result primarily from insects, fire, disease, and wind.

Losses due to reduced growth of forest crops are substantially higher than the direct mortalities. Destruction of seedlings and saplings by fire and other natural causes, damage to larger trees, and deterioration of soils reduce the productivity of forest lands and result in losses of potential growth amounting to 6.5 billion cubic feet annually, including about 25.7 billion board feet of sawtimber.

Serious losses of lumber and other forest products in buildings and other structures also result from fire and other natural causes.

Estimated annual losses of forest resources in the United States are given below.

Cause	Mortality: All Timber	Mortality: Sawtimber		Cull increase and growth loss		
	Million cu. ft.	Billion bd. ft.	Million dollars	Million cu. ft.	Billion bd. ft.	Million dollars
Fire	750	2.0	18	2,550	10.0	50
Insects 1/	950	4.5	54	50	0.2	2
Disease	150	0.7	6	1,400	5.5	50
Miscellaneous 2/	300	1.5	13	2,550	10.0	50
Total	2,150	8.7	91	6,550	25.7	152

1/ Cull increase and growth loss due to insects are believed to be considerably greater than shown, but information is lacking as a basis for more precise estimates.

2/ Wind, rodents, logging casualties, etc.

Fire Losses - Timber

About 3.5 million acres of forest land were burned over annually in the United States during the period 1942-51. This represented a loss

of all or part of the forest cover on about 0.7 percent of the Nation's commercial forest land. A considerably larger portion of the forest cover on noncommercial forest lands, of value primarily for watershed purposes, was also burned during this period. The volume of standing timber destroyed by forest fires is roughly estimated at about 750 million cubic feet annually--equivalent to more than a third of the annual timber requirements of the wood pulp industry of this country. Annual losses of sawtimber totaled about 2.0 billion board feet.

Far exceeding these losses of standing timber, however, is the loss of current and prospective timber growth or burned-over areas caused by the destruction of seedlings and small trees, by deterioration of site quality, by reduction in growth rates of damaged trees, and by increased cull in damaged trees. Largely as the result of past fires in the South, for example, forest lands are producing only about one-third of a cord of wood per acre annually, or one-third of the production possible with adequate fire protection and management to achieve full stocking. In the United States as a whole, the prospective loss from current forest fires is still probably at least 10 percent of the potential timber growth. This represents an annual growth loss in the neighborhood of 2.5 billion cubic feet, including about 10 billion board feet in terms of sawtimber size trees.

The values destroyed by forest fires are difficult to measure. They include the timber destroyed by fire, amounting to possibly \$18 million per year in terms of stumpage value, the additional reduction in possible timber growth, amounting to \$50 million, and numerous indirect effects. Destruction of timber raw material means lower industrial output and decreased payrolls in forest communities. Fires also take their toll in terms of losses of hunting and fishing values, lower yields of usable water, and increased erosion and flood damage. In many parts of the West such losses of watershed values far exceed the direct monetary values of timber destroyed.

The United States spends about \$50 million annually to prevent or suppress forest fires. About half of these costs are borne by States and counties, 30 percent by the Federal Government, and the remainder by private landowners.

A part of the tremendous losses from forest fires is attributable to lightning, but smokers, incendiarism, debris burning, and camp fires account for most of the damage. Losses from forest fires are for the most part preventable. They undoubtedly can be substantially reduced through research, public education, and more intensive control programs.

Table 19. Losses to Forest Trees, Nurseries, and Forest Products Due to Fire, Insects, Diseases, and Wind

Types of Losses	Actual Production			Loss of Production			
	Annual growth	Acreage	Value 1/	Percentage 2/	Annual growth	Value 1/	Acreage equivalent due to Loss 3/
	Million bd. ft.	1,000 acres	1,000 dollars	Percent	Million bd. ft.	1,000 dollars	1,000 acres
FOREST LOSSES							
Fire							
Mortality	-	-	-	-	2,000	18,000	-
Cull increase and growth	-	-	-	-	10,000	50,000	-
Sub-total for fire	35,300	460,000	317,700	25.4	12,000	68,000	116,840
Diseases							
Mortality	-	-	-	-	690	6,210	-
Cull increase and growth	-	-	-	-	5,510	49,590	-
Sub-total for diseases	(35,300)	(460,000)	(317,700)	14.9	6,200	55,800	68,540
Insects							
Mortality	-	-	-	-	4,480	53,760	-
Cull increase and growth	-	-	-	-	190	2,280	-
Sub-total for insects	(35,300)	(460,000)	(317,700)	11.7	4,670	56,040	53,820
Wind and miscellaneous							
Mortality	-	-	-	-	1,500	13,500	-
Cull increase and growth	-	-	-	-	10,000	50,000	-
Sub-total for wind, etc.	(35,300)	(460,000)	(317,700)	24.5	11,500	63,500	112,700
Totals							
Mortality	-	-	-	-	8,670	91,470	-
Cull increase and growth	-	-	-	-	25,700	151,870	-
TOTAL FOREST LOSSES	35,300	460,000	317,700	49.3	34,370	243,340	226,930
OTHER LOSSES							
Forest nurseries	-	-	-	-	-	160	-
Logs and lumber degrade	-	-	-	-	-	40,500	-
TOTAL OTHER LOSSES	-	-	-	-	-	40,660	-

1/ Values shown are estimates of stumpage sale values and are much less than those of lumber or finished products.
2/ Percentage lost from the volume of the potential annual growth if this cause of loss were eliminated.
3/ Computed from percentage of volume of potential growth lost.

Insect Losses — Timber and Forest Products

Losses of standing timber from attacks by insects are estimated at about 950 million cubic feet annually. In terms of sawtimber, losses are estimated at about 4.5 billion board feet. These losses reflect the sporadic outbreaks of bark beetles, some defoliators, and the less striking endemic losses due to the white-pine weevil, wood borers, and other forest insects. In monetary terms the loss of standing timber due to insects is roughly estimated at about $54 million annually.

In addition to direct losses of standing timber, there are other serious losses as yet unmeasured. Insect attacks lead to reduced growth, lowered quality of timber, and destruction of forest reproduction. Many outbreaks of defoliators may cause little direct mortality of trees but reduce their growth rate to a point where little wood is produced. Deformities caused by the white-pine weevil and increased cull due to damage by boring insects are reflected in lower commercial values of the timber crop. A large number of aphids, scales, and other sucking insects feed and injure trees by removing the plant juices. They cause damage by killing trees, reducing wood production, introducing disease organisms, or making them susceptible to secondary pests. Unfortunately, little is known of the extent of losses caused by these insects. Attack by weevils, sucking insects, and defoliators often results in inadequate stocking or complete destruction of future growing stocks. Seed and cone insects sometimes destroy practically all of a seed crop. The effect of insect injury on forest reproduction is not well known.

Heavy losses of forest products also result from insect attacks. From the time a tree is felled until it is finally used in structures, equipment, or furniture products, insects take their toll. Damage by termites, for example, requires large amounts of lumber for repairs and partial replacement. Control costs alone are estimated at $75.5 million annually. Many millions of dollars are spent in treatments to prevent termite damage. Ambrosia beetles and other wood borers attack green logs and lumber, causing losses during processing, storage, and use. Pulp logs are subject to attack, and heavy losses occur in storage. Powder post beetles attack stored lumber, furniture, and other wood products. It is estimated from the best information available that approximately $40.5 million is lost annually in processing of lumber in manufactured articles and in pulp storage.

Expenditures for the control of forest insects have averaged about $2.6 million annually over the last 10 years. About 75 percent of these funds have been provided by the Federal Government and the remainder by States and private agencies.

Disease Losses - Timber and Forest Products

Annual losses of standing timber due to forest diseases are estimated at about 150 million cubic feet, including nearly 700 million board feet of sawtimber. Heavy damage occurs year in and year out from attacks by a myriad of diseases. Heart rots are of particular importance, since they attack most species of timber and result in heavy losses in the form of cull and lowered quality of the remaining wood. Root rots and virus infections reduce growth and make trees susceptible to attacks by insects or subject to wind throw. Bark canker fungi, wilts, rusts, and various other diseases similarly destroy timber, inhibit growth, and lower tree quality.

Losses due to reduced growth and lowered quality because of disease are far greater than losses of standing timber. In the aggregate they total an estimated 1.4 billion cubic feet annually, including about 5.5 billion board feet of sawtimber. Altogether, losses due to forest diseases amount to possibly $56 million, of which $50 million represents cull increase and growth loss and $6 million loss of standing timber.

Other heavy losses of forest products also result from various diseases. Decay in buildings and other structures caused by improper construction, lack of wood preservation, and other factors annually destroys an estimated 10 billion board feet of lumber, plywood, and other timber products. About 6 percent of the pulpwood stored in northern pulp and paper mills is lost annually to decay. In monetary terms losses of timber products as a result of decay are much larger than in standing timber, because of the high value of finished products and the labor cost of replacement.

Expenditures for control of forest diseases averaged about $3 million annually during the last decade. Most of these funds have been provided by the Federal Government, and the remainder from State and private sources, and have been expended primarily for control of the white-pine blister rust.

Wind and Miscellaneous Losses -- Timber

Losses of standing timber from wind throw and miscellaneous causes, such as suppression and rodents, amount to an estimated 300 million cubic feet annually, including 1.5 billion board feet of sawtimber. A large part of these losses is due to major blowdowns, such as the blowdown of Douglas-fir in 1949-51. Part of the timber thus destroyed is salvaged. The value of the unsalvaged timber lost to wind and other causes, however, is roughly estimated at about $13 million annually.

In many areas reduction in timber growth and yields as a result of rodents is far more serious than the direct loss of standing

timber. Mice and other animals consume large quantities of seed of important species, such as ponderosa pine, preventing their reproduction and encouraging invasion of worthless brush. Failure of understocked stands and nonstocked areas to restock because of rodents and damage to live timber by porcupines, deer, and other animals causes losses in the form of reduced growth and lowered quality amounting to about 2.5 billion cubic feet annually, including about 10 billion board feet of sawtimber. These losses are valued at approximately $50 million.

Fire Losses -- Forest Products

Additional losses of lumber, plywood, and other forest products result from building fires. Approximately 25,000 dwellings in the United States are destroyed by fire each year, plus many farm buildings, industrial structures, and warehouses. The quantity of lumber and other forest products thus lost is about 40 million board feet annually, valued at about $4 million.

Infectious Diseases
(Tables 20 to 24)

Profitable livestock production is of considerable importance to the economy of any country. The losses due to diseases of animals in various countries of the world run into a high figure, and in some countries are so great that the food supply of animal origin is inadequate. Although vigorous efforts are made to keep these diseases to a minimum in the United States, the losses are still very serious.

In this country the responsibility for the control of diseases of animals rests with the Federal and State livestock sanitary officials with the assistance of practicing veterinarians, research workers, and the livestock owners themselves.

In the reports to follow an effort has been made to include estimates of annual livestock losses at the farm level from all causes for the period 1942-51, with separate estimates for disease-control costs. In general these losses include mortality, or death, losses and the even greater morbidity losses due to animal sickness. Morbidity causes loss of milk, eggs, wool, meat, and hides; loss of work days for horses; loss of feed consumed; labor for animal care and handling; loss of offspring not produced in some reproduction diseases; and replacement costs. Animal diseases also cause the livestock owner inconvenience and expenditures for which no estimate can be made.

In Tables 20 to 26, the use of several decimal places in recording the loss percentages is not intended to indicate a high degree of precision in the estimates, but to show the relative significance of the diseases listed. No percentage is given where the proportionate loss is less than 0.001 percent.

Virus Diseases of Livestock

A number of animal diseases are caused by viruses, which are so small that they cannot be seen through the ordinary microscope and which are capable of passing through filters that retain bacteria.

A number of viruses have been identified which affect different species of domestic animals. Some of them affect only one species, which makes research investigations very difficult because it eliminates the possibility of working with experimental animals. Examples of such diseases are infectious anemia of horses, hog cholera and vesicular exanthema of swine, and infectious dysentery of cattle. Other viruses affect two or more species, frequently

including man, such as rabies, equine encephalomyelitis, swine influenza, Q fever, and vesicular stomatitis.

A few virus diseases, such as hog cholera and horse sleeping sickness, frequently cause a very high death rate. Others, including infectious anemia of horses, vesicular exanthema of swine, ecthyma and scrapie of sheep, and the pox viruses, cause little mortality but affect production and usefulness of the animals. Still others, such as virus abortion of horses, may affect only the reproductive system.

The diagnosis, control, prevention, treatment, and eradication of these virus diseases depend on the scientific information available about them. The more that is known about a virus and its characteristics, the more successful will be the application of sound control measures. Sometimes a weak link in the life cycle can be broken to make control relatively easy; at other times nature has provided a much more complex and effective system for propagating the disease.

In addition to the high average annual loss from the virus diseases of livestock, large sums of money for antibiotics, sulfa drugs, other pharmaceuticals, disinfectants, biologics, etc., are paid to veterinarians, drug stores, feed stores, mail-order houses, and other distributors from whom there is no available means of obtaining reliable estimates.

For some of these diseases loss estimates could not be included in the tables, since information about incidence, mortality, and morbidity is not available. These diseases include infectious anemia and virus abortion of horses; Q fever, infectious dysentery, cow pox, and warts of cattle; scrapie and ecthyma of sheep; virus enteritis, swine pox, and influenza of swine. There are frequent field reports from livestock owners, veterinary colleges, experiment stations, and livestock sanitary officials, as well as in research publications, describing diseases highly suggestive of virus origin.

Because these diseases are difficult to recognize, their economic importance cannot be evaluated without an organized cooperative effort on the part of farmers, veterinarians, county agents, drug merchants, chemical, pharmaceutical, and biological companies, diagnostic laboratories, and State and Federal agricultural disease-control officials.

Bacterial and Mycotic Diseases of Livestock

Diseases caused by bacteria bring heavy losses to the livestock industry. Many of these diseases are enzootic in the United States, and only a few are being controlled by national programs.

Table 20. Losses to Cattle from Diseases

Cause of Loss and Unit of Production		Actual Production 1/		Loss in Mortality		Morbidity Loss in Value	Total Loss of Production	
		Quantity	Value	Production value	Percentage		Value	Percentage
		1,000 units	1,000 dollars	1,000 dollars	Percent	1,000 dollars	1,000 dollars	Percent
Anaplasmosis	(lbs.)	19,513,487 2/	3,431,538	3,500	0.102	6,000	9,500	0.276
Anthrax	(lbs.)	do	do	104	0.003	-	104	0.003
Bloat								
Animals	(lbs.)	do	do	15,530	0.450	23,295	38,825	1.119
Milk	(lbs.)	116,712,900 3/	4,228,375	-	-	4,228	4,228	0.099
Bovine hyperkeratosis (X-disease)	(lbs.)	(19,513,487	(3,431,538)	2,000	0.058	600	2,600	0.076
Brucellosis (Bangs)								
Animals	(lbs.)	do	do	-	-	45,000	45,000	1.294
Milk	(lbs.)	(116,712,900)	(4,228,375)	-	-	42,000	42,000	0.984
Cancer tumors		(19,513,487)	(3,431,538)	-	-	-	936 4/	0.027
Chemical poisoning	(lbs.)	do	do	4,000	0.116	500	4,500	0.131
Encephalitis (listeriosis)	(lbs.)	do	do	85	0.002	-	85	0.002
Foot rot	(lbs.)	do	do	-	-	195	195	0.006
Johne's disease	(lbs.)	do	do	88	0.003	106	194	0.006
Ketosis (acetonemia 5/)	(lbs.)	(116,712,900)	(4,228,375)	-	-	5,000	5,000	0.118
Leptospirosis								
Animals	(lbs.)	(19,513,487)	(3,431,538)	45,441	1.307	47,639	93,080	2.641
Milk	(lbs.)	(116,712,900)	(4,228,375)	-	-	19,202	19,202	0.452
Mastitis (galget)								
Animals	(lbs.)	(19,513,487)	(3,431,538)	11,657	0.339	38,601	50,258	1.444
Milk	(lbs.)	(116,712,900)	(4,228,375)	-	-	175,546	175,546	3.986

Poisoning (plants)	(lbs.):	(19,513,487)	(3,431,538)	1,842	0.054	1,842	3,684	0.107
Rabies	(lbs.):	do	do	62	0.002	-	62	0.002
Rejections (misc.)	(lbs.):	do	do	-	-	-	4,588 4/	0.133
Shipping fever	(lbs.):	do	do	1,621	0.047	23,379 6/	25,000 6/	0.723
Tuberculosis	(lbs.):	do	do	-	-	1,797	1,914 7/	0.056
Urinary calculi	(lbs.):	do	do	2,524	0.073	1,262	3,786	0.110
Vesicular stomatitis	(lbs) :	do	do	-	-	44	44	0.001
Vibriosis	(lbs.):	do	do	-	-	137,734	137,734	3.857
Wheat pasture	(lbs.):	co	do	1,000	0.029	-	1,000	0.029
TOTAL LOSSES DUE TO CATTLE DISEASES	(lbs.)							
Animals		19,513,487	3,431,538	89,454		327,994	423,089	
Milk		116,712,900	4,228,375	-	-	245,976	245,976	

1/ So far as possible the data represent the averages for the period 1942-51 as estimated by the Crop Reporting Board of the Agricultural Marketing Service. Where precise data were not available, best approximations were used.

2/ Total pounds of cattle and calves produced during the year. The total cattle population during the year (January 1 inventory plus calf crop) 115,206,000 head.

3/ Pounds of milk produced during year.

4/ Represents loss in value of meat only.

5/ Represents loss in milk production only.

6/ Includes a loss of $1,602,000 in meat.

7/ Includes a loss of $117,420 in meat.

Table 21. Losses to Swine from Diseases

Cause of Loss and Unit of Production	Actual Production		Loss in Mortality		Morbidity Loss in Value	Total Loss of Production	
	Quantity1/	Value	Production Value	Percentage		Value	Percentage
	1,000 units	1,000 dollars	1,000 dollars	Percent	1,000 dollars	1,000 dollars	Percent
Abscesses and blood poisoning (lbs.)	20,179,893 2/	3,473,817	-	-	-	1,242 3/	0.036
Anthrax (lbs.)	do	do	9	-	-	9	-
Atrophic rhinitis (sneezing sickness) (lbs.)	do	do	4,715	0.136	9,343	14,058	0.403
Baby pig losses 4/ (lbs.)	do	do	438,573	11.21	-	438,573	11.21
Brucellosis (lbs.)	do	do	-	-	10,000	10,000	0.287
Cancer tumors (lbs.)	do	do	-	-	-	54 3/	0.002
Chemical poisoning (lbs.)	do	do	432	0.012	52	484	0.014
Cholera (lbs.)	do	do	48,628	1.38	-	48,628	1.38
Erysipelas (lbs.)	do	do	-	-	24,314	24,314	0.695
Measles (lbs.)	do	do	-	-	1	1	-
Pasteurellosis (lbs.)	do	do	143	0.004	115	258	0.007
Poisoning (plants) (lbs.)	do	do	304	0.009	-	304	0.009
Rabies (lbs.)	do	do	2	-	-	2	-
Tuberculosis (lbs.)	do	do	-	-	-	801 3/	0.023
Vesicular exanthema 5/ (lbs.)	do	do	-	-	887	887	0.087
TOTAL LOSSES DUE TO SWINE DISEASES (lbs.)	20,179,893	3,473,817	492,806		44,712	539,615	

1/ See footnote 1 of Table 20.

2/ Total pounds of swine produced during year. The annual pig crop averaged 94,240,000 head.

3/ Represents only loss in value of meat n federally inspected plants.

4/ Includes losses from all causes.

5/ This disease occurred only in California for the period 1942-51.

Table 22. Losses to Sheep from Diseases

Cause of loss and unit of production		Actual Production		Loss in Mortality		Morbidity	Total Loss of Production	
		Quantity 1/	Value	Production Value	Percentage	Loss in Value	Value	Percentage
		1,000 units	1,000 dollars	1,000 dollars	Percent	1,000 dollars	1,000 dollars	Percent
Abscesses and blood poisoning	(lbs.)	1,694,303 2/	265,981	-	-	-	52 3/	0.019
Anthrax	(lbs.)	do	do	1	-	-	1	-
Bloat	(lbs.)	do	do	377	0.141	-	377	0.141
Cancer tumors	(lbs.)	do	do	-	-	-	2 3/	-
Circling disease	(lbs.)	do	do	57	0.021	-	57	0.021
Emaciation	(lbs.)	do	do	-	-	-	254 3/	0.096
Foot rot	(lbs.)	do	do	-	-	13	13	0.005
Grass tetany	(lbs.)	do	do	28	0.01	-	28	0.01
Poisoning(plants)	(lbs.)	do	do	256	-	128	384	0.144
Pregnancy disease								
Animals	(lbs.)	do	do	837	0.314	920	1,757	0.66
Wool	(lbs.)	(238,140)	138,181	-	-	5 4/	5	0.004
Rabies	(lbs.)	(1,694,303)	(265,981)	5/	-	-	5/	-
Urinary calculi	(lbs.)	(1,694,303)	(265,981)	567	0.213	-	567	0.213
Vibriosis								
Animals	(lbs.)	do	do	327	0.123	8,023	8,350	3.04
Wool	(lbs.)	(238,140)	(138,181)	-	-	230 4/	230	0.2
TOTAL LOSSES DUE TO SHEEP DISEASES								
Animals	(lbs.)	1,694,303	265,981	2,450		9,084	11,842	
Wool	(lbs.)	238,140	138,181	-	-	235	235	

1/ See footnote 1 of Table 20.
2/ Total pounds of sheep produced during year.
3/ Represents only loss in value of meat in federally inspected plants
4/ Includes some mortality losses where sheep die shortly before shearing time.
5/ Less than $500.

Table 23. Losses to Poultry Caused by Diseases

Cause of loss and unit of production		Actual Production 1/		Loss in Value		Loss in Quantity	
		Quantity	Value	Amount	Percentage of Potential Value	Number	Percentage of Potential Production
		1,000 units	1,000 dollars	1,000 dollars	Percent	1,000 units	Percent
Blue comb							
Chickens	(No.)	1,842,192 2/	2,909,334	4,377	0.15	3,113	0.17
Turkeys	(")	51,696 2/	239,668	1,870	0.77	857	1.65
Cholera							
Chickens	(")	(1,842,192)	(2,909,334)	8,064	0.28	6,342	0.34
Turkeys	(")	(51,696)	(239,668)	514	0.21	160	0.31
Eggs, low hatchability	(")	55,828,000	(1,845,797)	12,367	0.67	375,000 3/	0.67
Erysipelas							
Turkeys	(")	(51,696)	(239,668)	1,687	0.70	401	0.77
Infectious bronchitis							
Chickens	(")	(1,842,192)	(2,909,334)	7,055	0.24	12,450	0.67
Infectious sinusitis (air-sac infection)							
Chickens	(")	do	do	9,696	0.33	14,749	0.79
Turkeys	(")	(51,696)	(239,668)	3,034	1.25	1,322	2.49
Laryngotracheitis							
Chickens	(")	(1,842,192)	(2,909,334)	4,848	0.17	6,014	0.33
Lymphomatosis							
Chickens	(")	do	do	65,000	2.18	43,000	2.28
Mycotic disease							
Turkeys	(")	(51,696)	(239,668)	494	0.21	234	0.45
Newcastle disease							
Chickens	(")	(1,842,192)	(2,909,334)	24,012	0.82	45,822	2.43
Paratyphoid and paracolon infection							
Chickens	(")	do	do	198	0.007	147	0.008
Turkeys	(")	(51,696)	(239,668)	2,767	1.14	1,280	2.41

Pox							
Chickens	(No.)	(1,842,192)	(2,909,334)	1,239	0.043	875	0.047
Turkeys	(")	(51,696)	(239,668)	186	0.08	61	0.12
Pullorum disease							
Chickens	(")	(1,842,192)	(2,909,334)	9,024	0.31	16,078	0.87
Turkeys	(")	(51,696)	(239,668)	859	0.36	416	0.80
Tuberculosis							
Chickens	(")	(1,842,192	(2,909,334)	3,000	0.10	2,400	0.13
Typhoid							
Chickens	(")	do	do	6,514	0.22	5,837	0.31
Turkeys	(")	(51,696)	(239,668)	419	0.17	144	0.28
Other than infectious and parasitic diseases							
Chickens	(")	(1,842,192)	(2,909,334)	78,141	2.61	88,986	4.60
Turkeys	(")	(51,696)	(239,668)	3,307	1.36	1,459	2.74
TOTAL LOSSES DUE TO POULTRY DISEASES							
Eggs	(")	55,828,000	(1,845,797)	12,367	-	375,000	-
Chickens	(")	1,842,192	2,909,334	221,168	-	245,813	-
Turkeys	(")	51,696	239,668	15,137	-	6,334	-

1/ See footnote 1 of Table 20.

2/ Estimated total hatch during year.

3/ Annual loss in value was $12,367,000.

Table 24. Losses to Goats, Horses, Mules, Mink, and Rabbits

Cause of Loss and Unit of Production		Actual Production 1/		Loss in Mortality		Morbidity Loss in Value	Total Loss of Production	
		Quantity	Value	Production value	Percentage		Value	Percentage
		1,000 units	1,000 dollars	1,000 dollars	Percent	1,000 dollars	1,000 dollars	Percent
GOATS								
Brucellosis	(No.)	3,000 2/	15,750 2/	-	-	100	100	0.63
HORSES AND MULES								
Anthrax	(No.)	10,531 3/	835,852 3/	4	-	-	4	-
Cancer tumors	(")	do	do	4	-	-	4	-
Chemical poisoning	(")	do	do	54	0.006	20	74	0.009
Poisoning (plants)	(")	do	do	42	0.005	21	63	0.008
Rabies	(")	do	do	42	-	-	2	-
Sleeping sickness	(")	do	do	148	0.02	165	313	0.04
TOTAL LOSSES TO HORSES AND MULES	(")	10,531 3/	835,852 3/	254	0.322	206	460	.0582
MINK (Pelts taken)								
Bacterial diseases	(No.)	1,338 4/	25,208	504	1.960	-	504	1.960
Virus diseases	(")	do	do	504	1.960	-	504	1.960
Mismanagement	(")	do	do	397	1.550	-	397	1.550
Nursing sickness	(")	do	do	107	0.422	-	107	0.422
Urinary calculi	(")	do	do	55	0.217	-	55	0.217
Yellow fat	(")	do	do	65	0.257	-	65	0.257
Other nutritional Diseases	(")	do	do	384	1.500	-	384	1.500
TOTAL LOSSES TO MINK	(")	1,338	25,208	2,016	-	-	2,016	-
RABBITS								
Enteritis	(No.)	20,000	20,000	2,700	11.9	800	3,500	14.9
Mismanagement	(")	do	do	4,750	19.2	5/	4,750	19.2
TOTAL LOSSES TO RABBITS	(")	20,000	20,000	7,450	-	800	8,250	-

1/ See footnote 1 of Table 20.
2/ January 1 inventory of goats; value does not represent annual production.
3/ January 1 inventory of horses and mules; value does not represent annual production.
4/ Computed on basis of 92 percent of mink produced during year (1,454,000).
5/ Not estimated.

Many of them are insidious with a low mortality rate; consequently the losses are not glaringly apparent.

The mycotic (fungus) diseases are usually sporadic and occur most frequently under conditions most suitable for the fungi. Local outbreaks of those forms of granulomas, mastitis, dermatitis, lymphangitis, and stomatitis that are caused by pathogenic fungi sometimes cause heavy losses. Since there is little information on the incidence of mycotic diseases, the comments below relate only to bacterial diseases.

Anthrax

Anthrax is an acute, highly fatal disease of cattle, sheep, and horses, and it frequently assumes a chronic character in swine. The causative organism and its spores are infectious for man. The annual loss in cattle is $104,000, in horses $4,000, in swine $9,000, and in sheep about $1,000.

Brucellosis

In cattle the greatest losses from brucellosis are due to abortions, decreased milk supply, and sterility. It has been estimated that brucellosis costs the cattle industry $87 million annually, plus a control cost of $14 million. The loss due to sterility only is estimated at $59 million and is not included in the over-all loss estimate.

In goats losses are due to abortions, decreased milk supply, and sterility.

In swine the principal losses are due to abortions, sterility, and posterior paralysis.

Brucellosis is equally a public health problem, since man is also susceptible.

Erysipelas of Swine

This disease assumes various forms from subacute to chronic infection. The principal losses are due to death, loss of weight, and impaired growth. The causative organism is infectious for humans. The estimated annual loss is over $24 million.

Foot Rot

Foot rot causes lesions in the feet of cattle and sheep with consequent painful lameness. Affected animals lose weight and cows produce less milk.

Johne's Disease (Paratuberculosis)

This is one of the most insidious of the bacterial diseases of cattle. It is characterized by chronicity, intermittent diarrhea, emaciation, and eventual death. Diagnoses and control procedures are only moderately successful. The incidence is 2.5 percent, and the estimated annual cost is $194,000.

Leptospirosis

Losses in cattle caused by leptospirosis are due to death, weight loss, decreased milk production, and abortion. Although the disease was first diagnosed in this country within the last 10 years, the incidence of 5.6 percent indicates that it is highly contagious. The estimated annual loss is over $100 million.

A high incidence of leptospirosis has been diagnosed in swine in some sections of this country. It is apparently a symptomless disease in swine, but there is evidence that swine are the source of infection for cattle. The disease has also been diagnosed in horses and goats.

Mastitis of Cattle

Mastitis is probably the most important economic disease of cattle in this country. It is caused by numerous bacteria as well as by a pathogenic yeast. Losses are due to a decrease in milk production, loss of weight, animal replacements, and cost of treatment. The annual loss is estimated at over $225 million, not including the cost of treatment.

Pasteurellosis of Swine

The characteristic symptom of the disease is pneumonia. The annual loss is based on a 20-percent mortality of the diseased animals.

Shipping Fever of Cattle

The exact cause of this disease is not known. Losses are due to a decrease in weight and a 20-percent mortality of the animals infected.

Tuberculosis

Tuberculosis is usually a chronic disease of cattle and swine which eventually causes a loss in weight and in milk production, and a condemnation of carcasses if lesions are present. The causative organism is pathogenic for man.

Vibriosis

Vibriosis is responsible for approximately 40 percent of the infertility in cattle. This results in a decreased reproductive ability and milk production and a high replacement cost. Abortions are sometimes associated with the disease. The principal loss from vibriosis in sheep is due to abortions; however, the mortality may be high. There is also a decrease in weight and wool production.

Poultry Diseases
(Table 23)

Diseases of poultry levy a heavy toll. The losses include mortality, decreased egg productivity and fertility, and inefficient utilization of feed.

The relative importance of the different poultry diseases has changed in recent years. For instance, Newcastle disease seriously threatened the industry in the past decade. Then vaccination was developed which, although adding to the cost of raising poultry, has materially reduced mortality from the disease. Pullorum disease at one time caused the greatest losses in baby chicks. It has now been brought down to a very low incidence through the use of the rapid agglutination test for the detection of carrier birds.

Leucosis (lymphomatosis) causes losses several times as great as any other disease. Although extensive research has been conducted for a number of years, only limited headway has been made towards curtailing these losses. The total annual losses from poultry diseases exceed $240 million.

Noninfectious Diseases and Disorders
(Tables 20 to 24)

A large number of noninfectious diseases of livestock, particularly cattle, result in death losses, reduced gains, failure to grow, and the need for veterinary services. Some but not all of these troubles are of nutritional origin. Reports from a representative group of veterinarians in dairy sections showed that 70 percent of their calls to treat and advise on animal diseases were for those accepted as noninfectious. Since noninfectious diseases are not handled by State or Federal regulatory officials, except as they may affect the meat when the animal is slaughtered, no reports on them are required. This means that almost no information is available on the number of animals that sicken or die. About the only information on the losses they cause is that found in meat-inspection records that list tumors and various pathological alterations of the organs and tissues not associated with infectious diseases at the time of slaughter.

The greatest losses from these diseases are due to faulty management and feeding. In cattle bloat, milk fever, acetonemia, calving troubles, sterility from endocrine disturbances, and chemical poisoning are common. Sheep are also frequently lost from bloat, poisonous plants, chemical poisoning, ketosis or lambing paralysis, and urinary calculi.

Pasture-improvement measures that result in a lush growth of legumes have increased the losses from bloat; an effort has been made to determine these losses and they are included in the tables. Recently heavy losses from X-disease, or hyperkeratosis, of cattle have been reported in a number of States. Since this was once suspected as being an infectious disease, a number of official reports on losses due to it were available.

The increased use of agricultural chemicals, especially insecticides, herbicides, and fungicides, has directed attention to possible chemical poisoning as a cause of livestock losses. For this reason and because poisoning of livestock by lead, arsenic, selenium, fluorine, and poisonous plants has been reported from time to time by the Department of Agriculture and by some of the veterinary college clinics, an effort has been made to tabulate such losses.

Nutritional Disorders

Nutritional disorders of livestock and poultry vary widely in nature, distribution, and intensity, and in the resulting economic loss. Obviously they are dependent on the feed that the livestock and poultry consume. Nutritional diseases may result from a deficiency or excess of a single nutrient or of several nutrients. Sometimes they are complicated with other classes of diseases. The number of nutrients essential for animal life is large, including minerals, vitamins, proteins, amino acids, fats, and carbohydrates. Various metabolic and physiological factors, including hormones, which regulate body functions, are also involved. Accordingly, the number of possible nutritional disorders is extremely large. Many are ill-defined or unrecognized. Only a few are well described, and their regional or nationwide importance recognized.

The damage due to nutritional disorders may take the form of death, reproductive failure, impairment of growth, or lowered productivity of milk, eggs, or wool. The quality of the product - whether meat, milk, eggs, wool, or others - may be decreased. No exact figures of total losses are possible, because of the impossibility of segregating the diseases. Although feeding standards have been proposed or established for most classes of livestock, actual requirements for some of the needed nutrients are not yet known. Therefore, ideal rationing of animals is not yet possible, and there is no standard by which to judge farm production.

A few of the better known nutritional disorders can be described, however.

Baby Pig Losses (Table 21)

Losses of young pigs result not only from faulty nutrition, but from mismanagement and various infectious, parasitic, and other ill-defined causes. A significant percentage are born dead or survive only a few hours. Losses are heaviest during the first week of life. Chilling, failure to nurse, and injury and death directly traceable to the sow account for other losses. Various forms of enteritis, believed to be due to infections and nutritional factors, singly or in combination, stunt the growth or result in death of pigs. Most of the diseases that affect older swine also affect young pigs, generally with more pronounced damage. Metabolic and physiologic disturbances account for some of the losses in young pigs.

Because it was impossible to segregate the loss due to each disease of baby pigs, the total losses have been surveyed as a unit and are included in this section on nutritional disorders. That strict attention to nutrition, management, and sanitation can materially reduce losses has been shown by experiments in which farm losses of 33 percent up to time of weaning have been reduced to 10 percent. Epidemics may sweep through herds, however, and cause losses that sometimes reach almost 100 percent. The over-all financial loss, including runty pigs, is estimated at $438,573,000.

Bloat (Tables 20 and 22)

Bloat, a disorder affecting cattle, sheep, and goats, is especially prevalent among animals pastured on lush growth of legumes. It also occurs in animals being fattened in feed lots. There are methods of relieving affected animals if caught in time. Prevention of bloat among animals on pasture has generally meant use of mixed forage so that the clovers or alfalfa constituted less than half the available material. The onset of bloat is sudden; consequently death losses are rather high. Among fattening cattle and milking cows, there is a temporary reduction in rate of growth and in milk production of animals that recover.

Death losses among cattle may amount to 0.45 percent and the total losses, both in deaths and in impaired production, to 1.2 percent. In sheep, bloat occurs principally among flocks in the humid areas or on irrigated pastures. About 20 percent of the sheep in the country are found in such situations and bloat occurs in about 1 percent of the animals.

Grass Tetany (Tables 20 and 22)

Grass tetany, or wheat-pasture poisoning, occurs chiefly among cattle and sheep grazing on lush growths of green forages. During the last decade there have been severe losses in cattle grazed on green-wheat pasturage in the Texas Panhandle and losses in both cattle and sheep in Kansas and Oklahoma and adjoining areas. Losses have occurred on other small-grain pastures in Mississippi, as well as on perennial grass pastures in other parts of the country. The exact cause of this disorder is unknown, but it appears to be a physiological disturbance induced by the pasturage. The onset of the disease is sudden, and the animals generally die unless treatment is administered, such as injection of calcium gluconate or similar material.

In the wheat-growing areas of the Southwest, the disease fluctuates from year to year, depending on the weather and the growth of wheat during the fall and winter months.

Enteritis in Rabbits (Table 24)

Enteritis in rabbits has been tentatively classed as of nutritional origin, or at least as partially controllable by dietary means. It is characterized by listlessness, lack of appetite, diarrhea, rough hair coat, and related symptoms. Death losses are rather high, and gains of young rabbits are decreased. Antibiotic supplementation of rabbit diets appears to reduce the incidence of the disorder, but effective control is not yet a reality.

Ketosis (Table 20)

Ketosis, or acetonemia, is one of the most troublesome and widely distributed diseases of milking cows. Animals are generally affected early in lactation. They show loss of appetite, depressed appearance, loss of weight, and drop in milk production. Death losses are low. Methods of treatment that have been developed are reasonably effective but costly. Means of prevention through feeding are only partially effective. Like grass tetany, the disorder appears to be physiological, possibly induced by imbalance of feed nutrients. About 4 percent of the milking cows are sufficiently affected each year to require treatment.

Low Hatchability of Eggs (Table 23)

Each year low hatchability of poultry eggs entails serious economic losses. Much of this low hatchability is due to nutritional deficiencies or imbalances in the diets of the breeding flocks, particularly vitamin and mineral deficiencies. Genetics, physiology, and management also enter into the picture. The annual loss is estimated at 375 million eggs, or about 0.6 percent of total production, worth over $12 million.

Nursing Sickness in Minks (Table 24)

Nursing sickness affects a significant number of female mink each spring. They lose their appetites and consequently their weight, and the milk flow shrinks. Death losses are heavy among the females as well as their young. The nature of this disturbance is not known. The annual loss for the 1943-52 period is estimated at $107,000.

Urinary Calculi (Urolithiasis) (Tables 20, 22, and 24)

Urinary calculi occur principally among cattle and sheep, but losses are also serious among ranch-raised mink. In cattle the disorder is most common in range areas and in the feed lots, chiefly among steers. In sheep the principal losses are among wether lambs being fattened in feed lots.

The formation of stones, or calculi, in the urinary tract often leads to blocking of urine excretion. While progress is being made in research on its causes and prevention, methods of control are still relatively ineffective. Its incidence is rather erratic, although feed supplies in certain areas are becoming recognized as predisposing factor. Within specific areas there is considerable fluctuation from year to year that appears to be related to climatic conditions. The disorder is common on mink farms in the North Central States.

Yellow Fat in Mink (Table 24)

Yellow fat, or steatitis, in mink is now considered to be of nutritional origin. Affected animals show brownish yellow pigmentation in the body fat. The death rate is high and the pelt of poor quality. The disease occurs on diets high in unsaturated fats and low in vitamin E. Prevention appears to rest in reduction of unsaturated fats in the diet and increase in vitamin E content. Additional research is needed to develop practical means of dietary control.

Miscellaneous Nutritional Disorders

Other nutritional deficiencies of various types occur to a significant extent in all classes of livestock. Because of their numbers and complexity, they will be handled in a group. In several respects this miscellaneous group represents the true nutritional deficiencies in that a missing nutrient (or nutrients) is the seat of the trouble. There are also nutrient-excess disorders due to toxic effects of feed components.

Some of the nutritional-deficiency disorders are due to lack of sufficient quantities of any one of 15 or more vitamin factors. Among the more important vitamins found to be deficient are

vitamin A, especially in cattle, sheep, swine, and poultry; vitamin D for all classes except those exposed to sunshine throughout the year; niacin, riboflavin, pantothenic acid, and vitamin B_{12}. Under prolonged droughts vitamin A deficiency in beef cattle results in lowered calf crops, anasarca or edema in the meat, blindness, and deaths.

Mineral deficiencies may occur from lack of enough calcium, phosphorus, magnesium, iron, cobalt, copper, iodine, manganese, sodium, or chlorine. These deficiencies are generally associated with the soils and the crops grown in them, and thus with geographical areas. Various forms of anemia may be traced to lack of iron, cobalt, and copper; poor skeletal development, including broken bones, to insufficient calcium and phosphorus; and goiter in farm animals largely to lack of iodine. Low reproduction and slow growth result from a lack of several mineral nutrients. Meat, milk, egg, and wool production are likewise decreased.

Lack of feeds containing sufficient available carbohydrates and fats to yield energy and heat to maintain body functions also belongs in this category. Similarly, the protein content of the feed may be inadequate and lead to poor growth and low fertility. Because poultry and swine, especially, require specific amino acids, deficiency of any one of these acids may result in poor production.

The disorders caused by excesses of feed constituents include those due to selenium, arsenic, lead, fluorine, molybdenum, and iodine. Some elements - iodine, for example - are needed in minute amounts, but excesses may be toxic.

These miscellaneous nutritional disorders apply not only to livestock and poultry, but also to rabbits and fur-bearing animals. Some are much more likely to suffer than others. Development of exact feeding standards for all the essential nutritional factors could do much to eliminate the losses. No good estimate of present losses can be made. Perhaps a 5- or even 10-percent improvement in production is not unreasonable through elimination of these miscellaneous nutritional disorders.

Internal Parasites of Livestock and Poultry
(Table 25)

Livestock losses due to internal parasites occur in all parts of the country and in all seasons. However, the climate has much to do with the type, spread, and intensity of parasites, especially the weather from season to season. In general warmth, moisture, and shade favor parasitism. Control measures are based largely on taking advantage of the destructive effects of unfavor-

able climatic factors on the various stages of parasites. 1/

About 300 kinds of internal parasites are of economic importance to the livestock industry of the United States. Some of these parasites are very common and abundant, others extremely rare. 2/ Few animals are ever entirely free from them; many are the hosts of several thousand parasites, comprising a dozen or more injurious species. Losses occur in animals of all ages, but are heaviest in young stock, chicks, and turkey poults.

The specific ways in which losses are sustained on account of livestock parasites are legion, but a consideration of some of them, as outlined below, will emphasize the difficulty, if not impossibility, of arriving at accurate estimates, as well as the reasons for regarding all presently available information, however carefully assembled, as fragmentary.

Mortality Losses

Death losses of breeder, or farm, stock and of stock produced for market.

Morbidity Losses

(1) Reduced yield and depreciation of animal products--milk, eggs, hides, wool, mohair, casings, medicinal preparations.

(2) Condemnations of parts and carcasses under Federal or other meat inspection procedure.

(3) Waste of feed, labor, and space to bring animals to productive or useful maturity or to market.

(4) Interference with breeding and reproduction--sterility, diminished fertility and vigor, delayed conception, abortion, reduced litter size, lowered egg laying of chickens.

(5) Reduced quality of animals--lowered grades of market stock, reduced sale value.

1/ Lucker, John T. 1941. Climate in relation to worm parasites of livestock. In Climate and Man, 1941 Yearbook of Agriculture, pp. 517-527.

2/ Dikmans, G. 1945. Check list of the internal and external animal parasites of domestic animals in North America. Am. Jour. Vet. Res. 6(21): 211-241.

Table 25. Losses to Livestock and Poultry from Internal Parasites

Cause of loss and unit of production		Actual Production 1/ 2/		Loss in Mortality		Morbidity loss in value	Total Loss of Production	
		Quantity	Value	Production value	Percentage		Value	Percentage
		1,000 units	1,000 dollars	1,000 dollars	Percent	1,000 dollars	1,000 dollars	Percent
CATTLE								
Coccidiosis	(lbs.)	19,513,488	3,431,539	10,000	0.291	--	10,000	0.291
Gastroenteritis	(")	do	do	--	--	13,624	13,624	0.395
Liver flukes	(")	do	do	37	0.001	1,692	3,560 3/	0.106
Tapeworm and bladderworms	(")	do	do	--	--	--	58 4/	0.002
Trichomoniasis (bovine genital)	(")	do	do	--	--	750	750	0.022
Worm parasites	(")	do	do	8,989	0.261	--	8,989	0.261
Other parasitic diseases	(")	do	do	--	--	--	377 4/	0.011
TOTAL LOSSES TO CATTLE DUE TO PARASITES	(")	19,513,488	3,431,539	19,026		16,066	37,358	
GOATS								
Miscellaneous diseases								
Animals	(")	210,000	15,750	630	4.0	--	630	4.00
Mohair	(")	17,585	10,625	--	--	456 5/	456	4.00
HOGS								
Kidney worms	(")	20,179,893	3,473,817	--	--	66,376	72,772 6/	2.05
Parasites, internal	(")	do	do	17,300	0.496	61,239	78,539	2.229
Parasites, unclassified	(")	do	do	--	--	--	1 4/	--
Red worms	(")	do	do	7/	7/	10,476	10,476	0.301
Roundworms, large intestinal	(")	do	do	--	--	49,363	49,814 8/	1.414
Threadworms, intestinal	(")	do	do	--	--	25,912	25,912	0.74
Whipworms	(")	do	do	--	--	13,171	13,171	0.378

Worms, nodular	("):	do	do	--	--	24,941	26,041 9/	0.744
TOTAL LOSSES TO SWINE DUE TO PARASITES	("):	20,179,893	3,473,817	17,300		251,478	276,726	
HORSES AND MULES								
Roundworms, large	(No.):	10,531 10/	835,852 10/	--	--	2,000 11/	2,000 11/	0.239
Stomach worms	("):	do	do	--	--	1,000 11/	1,000 11/	0.119
Strongyles, bloodworms	("):	do	do	6,320	0.75	17,000 11/	23,320 11/	2.714
TOTAL LOSSES TO HORSES AND MULES DUE TO PARASITES	("):	10,531	835,852	6,320		20,000	26,320	
POULTRY								
Blackhead								
Chickens	(No.):	1,842,192 12/	2,909,334	149	0.005	--	149	0.005
Turkeys	("):	51,696 12/	239,668	3,815	1.57	--	3,815	1.566
Capillarids (turkeys)	("):	do	do	13	0.005	307	320	0.133
Coccidiosis								
Chickens	("):	(1,842,192)	(2,909,344)	8,400	0.288	29,475	38,229 13/	1.297
Turkeys	("):	(51,696)	(239,668)	420	0.175	46	466	0.194
Helminthiasis (chickens and turkeys)	("):	(1,893,888)	(3,149,002)	9	--	6	897 14/	0.028
Hexamitiasis (turkeys)	("):	(51,696)	(239,668)	574	0.24	93	667	0.278

Table 25. Losses to Livestock and Poultry from Internal Parasites (continued)

Cause of loss and unit of production		Actual Production 1/ 2/		Loss in Mortality		Morbidity loss in value	Total Loss of Production	
		Quantity	Value	Production value	Percentage		Value	Percentage
		1,000 units	1,000 dollars	1,000 dollars	Percent	1,000 dollars	1,000 dollars	Percent
POULTRY (Contd)								
Intestinal roundworms (chicks and turkeys)	(No.)	(1,893,888)	(3,149,002)	100	0.003	183	283	0.009
Leucocytozoon Turkeys	(")	(51,696)	(239,668)	708	0.29	--	708	0.294
Tapeworms (chickens and turkeys)	(")	(1,893,888)	(3,149,002)	--	--	739	739	0.023
Trichomoniasis Turkeys	(")	(51,696)	(239,668)	41	0.017	6	47	0.02
TOTAL LOSSES TO POULTRY DUE TO PARASITES	(")	--	--	14,229		30,855	46,320	
SHEEP								
Coccidiosis	(Lbs.)	1,694,303	265,981	1,206	0.451	--	1,206	0.451
Gastroenteritis, parasitic								
Animals	(")	(1,694,303)	(265,981)	14,729	5.25	8,000	22,729	7.87
Wool	(")	238,140	138,181	--	--	4,568 15/	4,568	3.19
Liver flukes	(")	(1,694,303)	(265,981)	2,449	0.912	1,978	4,650 16/	1.718
Lungworms								
Animals	(")	do	do	754	0.283	798	1,552	0.580
Wool	(")		(138,181)	--	--	459 5/	459 5/	0.332
Nodular worms								
Animals	(")	do	(265,981)	2,889	1.074	3,124	6,531 17/	2.396
Wool	(")		(138,181)	--	--	1,812 5/	1,812 5/	1.294
Tapeworms	(")	do	(265,981)	--	--	--	619 4/	0.232
Other parasites	(")	do	do	--	--	200	200	0.075
TOTAL LOSSES TO SHEEP DUE TO PARASITES								
Animals	(")	1,694,303	265,981	22,027		14,100	37,487	
Wool	(")	--	138,181	--	--	6,839	6,839	
TOTAL LOSSES TO LIVESTOCK AND POULTRY DUE TO PARASITES		--	10,469,144 18/	79,532		339,794	432,136	

1/ Average annual quantity and value of production during 1942-51.
2/ Total number of pounds produced during year.
3/ Includes a loss of $1,831,150 in meat.
4/ Represents loss in value of meat only.
5/ Includes some mortality losses.
6/ Includes a loss of $6,396,100 in meat.
7/ Not estimated.
8/ Includes a loss of $451,416 in meat.
9/ Includes a loss of $1,100,000 in meat.
10/ January 1 inventory of horses and mules.
11/ Value of animal - workdays lost.
12/ Total hatch during year.
13/ Includes a loss of $353,560 in eggs.
14/ Includes a loss of $882,000 in eggs.
15/ Includes some mortality losses in cases where sheep die shortly before shearing time.
16/ Includes a loss of $223,000 in meat.
17/ Includes a loss of $518,000 in meat.
18/ Not including the value of horses, mules, and goats.

(6) Lowered efficiency of work animals, such as horses and mules.

(7) Depreciation of capital items--breeder animals, farm properties, abandonment of production.

(8) Inefficient utilization of pastures, barns, and pens by unproductive stock.

(9) Lower resistance of infected stock to other diseases and parasites.

(10) Deaths, sufferings, and anxieties imposed upon man by parasites transmitted from domestic animals, or by diseases carried by parasites that are primarily animal rather than human.

(11) Expenditures for worthless or inefficient drugs, treatments, and equipment.

Control Costs, or Charges Ascribable to Protection Against Parasites

(1) Expenditures for drugs for treatment, prevention, eradication, and control.

(2) Cost of veterinary and other services, and of labor for administering drugs and effecting control.

(3) Expenditures to prevent parasite introduction.

(4) Expenditures for research--Federal, State, and private.

(5) Cost of regulatory services (Federal, State, and other), including inspection and quarantine of animals, meat inspection, and litigation.

Recent years have witnessed more and more instances in which parasites have been found to be the principal agents in causing disease outbreaks characterized by severe morbidity and heavy death losses. Yet now, more than at any time heretofore, there is also a fuller understanding of the less spectacular ways in which these marauders have a significantly greater economic impact upon the livestock industry. Because they are ubiquitous and unseen, of great variety and abundance, and their effects generally inapparent, internal parasites undermine the health of countless thousands of food animals and are a constant hazard to efficient, profitable production. Vigilance against parasites is therefore accepted as an essential aspect of efficient management. There is no way in which the hidden losses can be adequately estimated or even fully comprehended, and we have not attempted to estimate either the cost of measures directed toward their control or the benefit accruing from them.

Much of the loss from both diseases and parasites is preventable by known means, and much more can presumably be prevented by further research. 3/ 4/ This conviction is probably the basis of a recent estimate that preventable losses may amount to about 10 percent of the annual value of livestock production, or a loss that may conservatively be said to amount to over $2 billion. About half of this may be ascribed to parasites, of which there are external as well as internal species.

Among the principal objectives of the estimates in Table 25 of losses due to individual internal parasites were conservatism and reliability, and an examination of the over-all picture outlined above suggests that these estimates may be far too low. In general, mortality and morbidity losses were well considered, whatever degree of accuracy may have been attained. On the other hand, losses due to control expenditures were not included, except for a few parasites affecting horses and poultry.

The major items considered were (1) kinds or categories of parasites affecting each class of livestock; (2) their occurrence, distribution, and relative capacities for causing economic loss; (3) the nature of economic losses from parasites; (4) the ways in which the individual parasites injure their hosts; (5) estimates by the crop-reporting services of total disease and parasite losses 5/ 6/; (6) official data on populations and value of annual production of the several classes of livestock in the United States; and (7) individual judgments of authorities on the comparative importance of diseases and parasites as causative factors of economic loss among the several classes of livestock.

Insect Pests of Livestock and Poultry (Table 26)

The abundance of several of the livestock insect pests varies little from year to year. Weather may shorten or lengthen the active season of biting flies, but on a countrywide basis live-

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3/ Foster, A. O. 1951. Internal parasites of livestock. Proc.. U. N. Sci. Conf. on Conserv. and Util. Resources (1949), v. 6, Land Resources, pp. 481-485.

4/ Foster, A. O. 1953. Critical review of present-day treatments of parasitic infections, giving lists of drugs. Proc. XV Internatl. Vet. Cong., v. 1, pt. 1, pp. 458-468.

5/ Mohler, John R.,et al. 1942. Losses caused by animal diseases and parasites. In Keeping Livestock Healthy, Yearbook of Agriculture 1942, pp. 109-116.

6/ Nordquist, A. V. 1947. Estimating livestock losses. Proc. 50th Meeting of U. S. Livestock Sanitary Assoc. 1946, pp. 199-208.

Table 26. Losses to Livestock and Poultry Caused by Insects

Cause of loss and unit of production		Actual production[1/]		Loss of production	
		Quantity	Value	Value	Percentage
		1,000 units	1,000 dollars	1,000 dollars	Percent
CATTLE					
Grubs	(Lbs.)	19,513,487[2/]	3,431,538	100,000	2.83
Lice	(")	do	do	20,000	0.58
Horn fly	(")	do	do	150,000[3/]	4.19
Horse and deer flies	(")	do	do	75,000	2.14
Scabies mites	(")	do	do	4,500	0.13
Stable fly	(")	do	do	20,000	0.58
Ticks	(")	do	do	13,800	0.40
TOTAL LOSSES DUE TO CATTLE INSECTS	(")	19,513,487	3,431,538	383,300	
GOATS					
Lice and mites (loss of mohair)	(lbs.)	17,585	10,625	800	7.00
ALL LIVESTOCK					
Screw-worm		-	-	20,000	-

POULTRY (Farm chickens and broilers)					
All insects	(No.)	1,445,801 4/	1,063,537	80,212	7.0
SHEEP					
Bots	(lbs.)	1,694,303 2/	265,980	8,000	2.92
Ear Ticks	(")	do	do	1,300	0.49
Keds	(")	do	do	7,500	2.74
Lice	(")	do	do	1,500	0.56
Mites	(")	do	do	2,000	0.75
TOTAL LOSSES DUE TO SHEEP INSECTS	(")	1,694,303	265,980	20,300	
SWINE					
Lice and Mites	(")	20,179,893 2/		3,100	0.09
TOTAL LOSSES TO LIVESTOCK AND POULTRY DUE TO INSECTS					
Animals			4,761,055	506,912 5/	
Mohair		17,585	10,625	800	

1/ See footnote 1 of Table 20.

2/ Total pounds produced during year.

3/ Including losses in milk production.

4/ Total head produced during year.

5/ Represents morbidity loss in value only.

stock are seldom completely free from insects. Outbreaks do occur, but there is usually no markedly reduced infestation the following year, except in the case of the screw-worm in the Northern States, which are invaded in some years.

The injury that insects do to livestock is usually not so apparent as injury done to plants. The grower may see his livestock fighting flies, but not understand that losses in weight and milk will result. House flies, stable flies, horse and deer flies, cattle grubs, lice, and screw-worms cause reduction in yield due to fighting and running from them and reduced feeding. In addition, hides and meat are damaged by cattle grubs, and wool and mohair of sheep and goast by lice and sheep ticks.

Cattle

Cattle grubs are distributed over the entire United States, but especially in the North, where two species are involved. They cause losses in cattle in three ways:

(1) Damage to hides. A large proportion of the hides taken during the grub season (6-8 months) have five or more grub holes and are classed as No. 2 grade. The grower takes the loss, but is seldom aware of the degrading.

(2) Loss of meat in dressed carcasses. Buyers down-grade cattle purchased during grub season. Two or three grubby animals in a lot are reported to lower the price of the entire lot as much as $5 per head in some stockyards.

(3) Running from flies. Cattle occasionally jump, run, and stampede over or into fences and injure themselves during the heel fly season (2-4 months). The loss in weight and milk production among cattle severely attacked is estimated at 10-20 percent.

The average annual loss in cattle due to the cattle grub is estimated at $100 million.

Lice cause beef and dairy animals to rub and lick or bite themselves. Lousy animals are unthrifty and do not utilize feed for proper gains. Little information is available on the reduction of weight gains or milk production due to lice. Snipes 7/ showed

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7/ Snipes, B. Thomas. 1948. One-treatment control for cattle lice. Agr. Chem. 3(9): 30-34.

that treated animals gained 73 pounds more per head than untreated checks under identical management, range, and handling conditions over a period of 61 days. Much more work of this nature is needed. However, if 10 pounds per animal is lost in only 10 percent of the cattle in the United States, an annual loss figure of $20 million is reached.

Several species of ticks affect cattle, especially in the South and West. They reduce weight gains and heavy infestations sometimes kill the animals. Ticks also predispose cattle to screwworm attack by breaking the skin. Losses in cattle due to ticks are estimated at $13,800,000 annually.

Four species of mites cause an estimated annual loss of $4,500,000.

Goats and Swine

Lice and mites on goats cause $800,000 annual loss through reduced weight gains and unthriftiness. There is also a loss of mohair due to rubbing against fences and other objects. The loss caused by this group of pests on swine is estimated at $3,100,000 yearly.

Poultry

About 40 species of mites and 10 species of ticks and fleas affect poultry in the United States. These pests cause unthriftiness, loss of weight and egg production, and some mortality, especially in young stock. Edgar and King 8/ studied the effect of one species of louse on egg production, body weight, and food consumption in Alabama. He concluded, "The difference in net income between louse-negative and louse-positive flocks could be 30 to 40 percent. This could mean approximately 75 to 85 cents more per louse-negative bird." The average annual loss to the poultry industry has been estimated at $80 million.

Sheep

Mites, bots, lice, keds, and ticks take a toll of sheep in reduced weight gains and wool production and in general unthriftiness.

Miscellaneous Insect Pests

Mosquitoes are a constant source of annoyance to cattle, and occasionally livestock has been killed by swarms of mosquitoes.

8/ Edgar, S. H. and D. F. King. 1950. Effect of the body louse, Eomenacanthus stramineus, on mature chickens. Poultry Sci. 29(2): 214-219.

In many places they prevent cattle from grazing and the constant irritation of bloodsucking reduces weight gains and milk yields. With the large increase in irrigated pastures in the West, mosquitoes have multiplied and created problems to the livestock owner. No estimates are available on the losses that mosquitoes cause to livestock, but they are sizeable and are likely to increase.

Three species of bot flies attack horses, causing them to be nervous and difficult to manage. The larvae, which inhabit the stomachs of horses, no doubt cause loss of weight and unthriftiness.

Screw-worms are found from southern California to South Carolina. They cause the most injury to stock in the South, but nearly every year they invade the Midwestern States as far north as South Dakota. Screw-worms will kill animals if they are not cared for and their wounds treated. The largest loss to the grower arises from the constant vigil necessary (5-8 months in Texas) to find infested animals and care for them. The ranchers must employ riders to look over the stock every few days and care for infested animals. This extra labor costs many times as much as the chemicals used in treatment of wounds. Exclusive of this cost, the losses due to screw-worms (death, permanent injury, poor weight gains) are estimated at $20 million annually.

Black flies are bloodsucking insects of livestock that at times actually kill animals because of huge swarms present. They are present in many places over the United States, but usually they are unnoticed because they feed on stock during the night. No doubt these bloodsucking pests have a deleterious effect on animals.

Horn flies are distributed over the entire United States. They suck blood, causing irritation, and cattle fight them with a consequent loss of weight gains and milk flow. Stock suffer 2 to 6 months of the year from this pest, depending on the latitude. Experiments by Laake 9/ showed that beef cattle treated with DDT gained 50 pounds more in one month than similarly infested animals not treated. Knipling 10/ estimated an annual loss of at least $100 million in beef cattle and $50 million in milk production

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9/ Laake, E. W. 1946. DDT for the control of horn flies in Kansas. Jour. of Econ. Ent. 39:65-68.

10/ Knipling, E. F. 1954. The need for controlling livestock pests. Amer. Chem. Soc., Advances in Chemistry Series. (In press).

due to horn flies.

Stable flies are distributed over most of the United States, but the severity of attack is greatest in the South and Midwest. These flies torment animals from 2 to 6 months of the year and cause them to fight the insects with consequent loss in production. No experimental data on losses are available, but they are estimated to be about $20 million annually.

Horse flies and deer flies are vicious pests in the South, Midwest, and some places in the West. There are many species and they differ in biting habits, some attacking the head, some the back, and others the abdomen and legs. They are large insects and draw much blood, causing irritation and fighting. Even the buzzing of these flies around animals causes uneasiness and a tendency to improper grazing. Control measures are unsatisfactory. Losses are estimated at $75 million annually.

Marketing and Processing Losses
(Table 27)

During the marketing and processing of the products of livestock and poultry, losses are incurred from accidents, lack of care, deterioration, and spoilage.

No data are available on the losses from such causes during the distribution of beef, pork, mutton, lamb, and fur products.

Market Egg Defects

Defects such as meat and blood spots occur in eggs wherever they are produced. Faulty nutrition is suspected as being a factor, as well as genetics, management, and physiological disturbances. As much as 0.7 percent of the eggs produced may show these spots.

Other losses arise from breakage, and from downgrading due to shell abnormalities, dirt, and spoilage.

Liquid eggs are subject to a further loss from incomplete recovery of the contents, since an average of 11 percent of the yolk and albumen remain with the discarded shells.

Accidents, Bruising, and Downgrading of Poultry

Marketed poultry are subject to downgrading from cuts and bruising, poor conformation, discoloration, pinfeathers, and poor condition due to lack of skill in handling. A study made by the Department in 1953 indicates that losses from such causes amount to about 11.5 percent of the value of the birds.

Table 27. Losses in Marketing and Processing of Poultry Products

Cause of loss and unit of production		Actual Production		Loss in Value	
		Quantity	Value	Amount	Percentage
		1,000 units	1,000 dollars	1,000 dollars	Percent
EGGS					
Broken	(No.)	48,393,000 1/	1,606,590 1/	53,017	3.3
Defects	(")	do	do	11,246	0.7
Grade reductions	(")	do	do	44,985	2.8
Liquid eggs, incomplete recovery	(lbs.)	(813,253)	(243,926)	26,832	11.0
TOTAL EGG LOSSES		48,393,000	1,606,590	136,080	8.5
CHICKENS AND TURKEYS					
Grade reductions for bruises, cuts, etc.		953,972 2/	1,150,077 2/	132,259	11.5

1/ Average number and cash value of eggs sold annually 1942-51.

2/ Average number of farm chickens, commercial broilers, and turkeys sold 1942-51, and cash receipts from such sales.

Summary of Losses to Livestock and Poultry

The estimated losses to livestock and poultry during production and marketing are summarized in Table 28.

It is generally recognized that about 70 percent of the feed for animals comes from cropland and about 30 percent from pasture and range. Of the total returns of $15,717 million in the industry, $11,002 million may accordingly be credited to cropland and $4,715 million to pasture and range. Similarly, of the losses of $2,688 million, about $1,882 million may be considered a loss of cropland products, and $806 million as a pasture and range loss.

It is impracticable to compute acreage equivalents of livestock losses independently of the similar equivalents of crop losses. The equivalent of cropland acreage lost from animal diseases and other livestock losses was based on the potential production of United States cropland, determined as follows:

	Million dollars	
Crop value (see Chapter III)............	11,555	
Livestock returns credited to cropland..	11,002	
Total returns from cropland..........		22,557
Crop losses during production, storage, and distribution (see Chapters IV to VIII, and Table 35)..................	9,473	
Livestock losses, effect on cropland products............................	1,882	
Total losses of cropland products.....		11,355
Potential production from cropland if no losses had occurred................		33,912

Livestock losses of $1,882 million constitute 5.55 percent of the total potential production from cropland. This percentage of the total of 357,835,000 acres of cropland in the United States is 19,859,000 acres, the acreage equivalent of livestock losses. That is, the potential return from 19,859,000 acres of cropland was lost because of the diseases, insect pests, and internal parasites of livestock and the market downgrading of livestock products due to quality deterioration.

Table 28. Summary of Estimated Annual Livestock and Poultry Losses for 1942-51

Nature of Loss	Table No.	Production Value	Losses in Value	Percent loss from potential production
		1,000 dollars	1,000 dollars	Percent
Cattle diseases - Losses in production of meat, hides, and milk	20	7,659,913	669,065	8.0
Swine diseases	21	3,473,817	539,615	13.4
Sheep diseases - Losses in production of meat and wool	22	404,162	12,077	2.9
Poultry diseases - Losses in production of meat and eggs (including non-hatchability of eggs)	23	3,149,002	248,672	7.3
Goat, horse and mule diseases	24	851,602 1/	560	0.1
Mink and rabbit diseases	24	45,208	10,266	18.5
Internal parasites of livestock and poultry	25	14,742,727	432,136	2.8
Insect pests of livestock and poultry	26	4,771,680	507,712	9.6
Marketing losses in poultry products	27	2,756,667	268,339	9.7
Livestock industry as a whole		15,717,000 2/	2,688,442	

1/ Average January inventory value; not included in annual income totals.

2/ Average annual farm marketings of livestock and products plus value of home consumption, 1941-52.

CHAPTER XI. SOILS

Losses on Cropland

Agricultural losses due to soil deterioration, while of considerable local importance in many areas of rangeland and timberland, reach significant national proportions primarily on land used for cultivated crops. For the period 1942-51 this cropland area, including rotation pasture, averaged about 450 million acres. 1/

In this discussion consideration is given primarily to losses which arise essentially from physical soil deterioration, not including the unrelated losses of replaceable organic matter and plant nutrients which are the normal result of crop production. These types of soil deterioration include erosion by runoff water, blowing (wind erosion), deterioration of structure, alkali accumulation, and waterlogging. Such losses are assumed to be preventable. (Table 29)

As serious as are the production losses arising from these causes, they are minor in comparison with the tremendous increase in production attainable were all farmers to make the fullest efficient use of all the land, labor, and capital available.

Additional agricultural losses involving cropland, which are not considered here, include the extensive areas deliberately inundated by permanent dam backwaters and the estimated 250,000 acres of cropland absorbed annually by urban and industrial expansion and by highway and airport construction. Nor is consideration given here to areas where low soil productivity is a natural consequence of an original state of infertility, alkalinity, droughtiness, acidity, high water table, massive structure, even though such soil deficiencies can often be corrected by proper soil management. Losses from flooding and sediment deposition on cropland are discussed later in this chapter under "Watershed Damages, Including Floodwater and Sediment."

The different causes of soil deterioration generally occur, not singly, but in combination. Alkali accumulation, for example, is commonly associated with waterlogging and with impaired soil structure. Similarly, soil erosion nearly always involves loss of organic matter. Therefore, in evaluating broadly the effects of soil deterioration, it is not possible to make any sharp distinction as to the specific individual effects. Although the various

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1/ Cropland in 1950 is reported by the U. S. Census as 409 million acres, including idle and unharvested land but "exclusive of cropland used only for pasture in 1949." The 450 million acre average for 1942-51, referred to in this chapter, includes such rotation and irrigated pastures on farms as are sometimes used for the production of cultivated crops. In other chapters reference is made to 358 million harvested acres, a term that excludes idle and unharvested land.

Table 29. Losses to Soil from Deterioration, including Erosion, and Watershed Damage

Nature of Losses	Annual Loss in Value		Limits of Probability Expressed as Percentage of Estimates
		1,000 dollars	Percent
Soil deterioration on cropland		750,000	60-200
Soil erosion:			
On grazing land	180,000		
On forest land	25,000		
SUBTOTAL		205,000	60-200
Watershed damage, including floodwater and sediment		557,000	85-125
TOTAL FOR SOIL LOSSES		1,512,000	

types are recognized and have been measured in many local situations, highly reliable data are lacking as to the magnitude and distribution of the aggregate losses on a national basis.

Even if such data were available in physical terms, no satisfactory method has yet been devised for the precise evaluation of the economic effects of such losses to the farmer and to the consuming public. Under the conditions of inelastic demand which so frequently characterize the agricultural "economy of scarcity," the full social value of agricultural production, or of any diminution of such production, cannot adequately be expressed by the price tag of the market value. With full regard for these limitations, an attempt has been made to aggregate loss estimates in terms of physical losses and their economic evaluation. The nature and extent of losses due to various causes are then described.

Physical Losses

Estimates of the physical soil loss from cropland for the base period run as high as 4 billion tons per year. One-third to one-fourth of this amount ultimately enters the major stream system, with resultant damages from flooding, sedimentation, etc. About 35 million acres of land originally suitable for cultivation have been rendered unfit even for temporary cultivation by the various types of soil deterioration, principally soil erosion. For the base period the annual rate of such cropland loss is estimated at 500,000 acres per year. In addition, 50 to 100 million acres of land, once cultivated but not originally entirely suitable for long-time cultivation, have been so severely affected that they are no longer in cultivation.

On land that has remained in cultivation, soil deterioration has given rise to losses of a much more serious nature, in terms of decreased yield and increased costs. A survey by the Soil Conservation Service in 1948 indicated the following conditions on the 450 million acres of cropland at the current rate of soil deterioration:

Degree of deterioration	Million acres	Number of years in which land would be degraded one capability class 1/ if no remedial measures were taken
Critical	114	10-15
Serious	120	15-30
Slight to none	216	30 plus

1/ Based upon the SCS land-capability classification, which is a systematic arrangement of different kinds of land according to properties that determine their capability to produce permanently.

It should not be inferred from these estimates that, during the base period, soil deterioration was occurring on the entire acreage of cropland. Actually, millions of acres in the slight-to-none category were being maintained and even improved through sound management practices, including soil conservation.

Economic Losses

Although there is no completely satisfactory method for the economic interpretation of physical soil deterioration on cropland on a national scale, various estimates have been made. The annual losses from erosion alone, in terms of the cost of replacing, through commercial fertilizers, the major nutrient elements removed through soil erosion have been estimated at several billion dollars. The cost (at 1947 prices) of replacing only the nitrogen and phosphorus is estimated by investigators of the Department at $4.3 billion, and of replacing the nitrogen, phosphorus, and one-fourth of the potassium at $7.75 billion. This does not take account, however, of large supplies of these nutrients uncovered in many soils by both natural and accelerated erosion. The effects on the physical properties of the soils are more important than the effects on their chemical composition. Another estimate in 1947, based upon the decrease in value of cropland from soil deterioration, placed the annual loss for the base period in the order of $1 to $1.5 billion (Hearings before the Subcommittee of the Committee on Appropriations, House of Representatives, 80th Congress, First Session, April 8, 1947).

Assuming that the figures given for the various degress of deterioration in 1948 applied throughout the base period, and that soil deterioration losses were capitalized into decreased cropland value, on the basis of an average cropland value of $75 per acre, the estimated annual loss figure is about $750 million. This estimate is merely a suggested central value in a probable range of 60 to 200 percent. If the equally rough estimates of $180 million for such losses on grazing land and $25 million on forest land are included, the total approaches $1 billion.

The total value of farm real estate ranged from $38 billion in 1942 to $86 billion in 1951, with an average value of about $65 billion. 2/ Against this figure the soil deterioration estimates represent a loss of 1 to 2 percent. (Some of the losses on range and timber lands occurred on areas not in farms and hence, not included in the $65 billion.)

It should not be inferred, however, that such losses of 1 to 2 percent of the dollar value of farm real estate imply that another 50 or 100 years will see the value approaching zero.

2/ Current Developments in the Farm Real Estate Market U. S. Bureau of Agricultural Economics, July 1953.

The loss estimates might be considered net in terms of the anti-deterioration measures then in effect, but not including possible measures to bring new land into production and to increase the productivity of the existing cropland.

During the base period about 1 million acres were added annually to the Nation's cropland over and above the loss of 500,000 acres from soil deterioration and 250,000 acres from urban and industrial encroachment. In addition, much of the cropland listed as subject to little or no deterioration was undergoing improvement through physical and management inputs.

Nor should the annual rate of loss necessarily be considered constant. Expanded applications of conservation and reclamation measures, of course, would reduce the rate of loss, and any slacking off of such applications would result in a higher rate. In 1942 the national soil and water conservation program was in its early stages. The extent to which the effects of this program were being felt during the base period is indicated by the following acre-equivalents of land upon which conservation had been applied by farmers and ranchers cooperating with soil conservation districts:

	Calendar Year	Cumulative
1942	7,942,000	15,834,000
1951	25,620,000	150,066,000

While the job of applying and maintaining conservation measures on the Nation's farmland remains a tremendous one, the figures above show clearly that the trend in the application of such measures has been steadily upward.

As already indicated in the introductory paragraphs of this chapter, land value is not necessarily a valid measure of the productive condition of the soil. The total value of farm real estate in the United States is affected by soil deterioration, by soil improvement, by increased productivity due to increased use of inputs other than land, and by changes in management. However, changes in the total market value are influenced much more by fluctuations in the general level of prices and through the interplay of supply and demand for land and the products of land. A look at farmland values over the last 30 years shows the following cyclical changes:

> From a high of over $66 billion in 1920, the total reported value of farm real estate dropped to $30 billion in the depression year of 1933. By 1952, however, without any large change in total acreage, the total value had trebled to $94 billion. It is somewhat lower now, the drop from July 1952 to July 1953 being about 4 percent. Clearly, such wide fluctuations tend to mask the effects of soil deterioration and of offsetting factors of soil improvement.

Soil Erosion

Soil erosion has forced the abandonment for cultivation of an estimated 25 million acres of land that was originally suitable for crop production. For the base period the rate of such loss was 500,000 acres per year. In addition, perhaps 75 million acres once cultivated but not originally well suited to cultivation have been rendered unfit even for occasional cultivation. On the remaining cropland, erosion continues to take its toll of productivity.

The effects of physical soil loss upon crop yield vary widely with soil type, the kind of crop grown, and the nature and amount of other inputs. Clearly, a loss of several inches of topsoil from a shallow stony soil with the resultant exposure of bare rock would be agriculturally disastrous. On the other hand, a similar loss from a deep, fertile grassland or alluvial soil might result in decreased yield and land value but probably not in abandonment.

Of the 450 million acres used for crops and rotation pasture in the base period, about 80 percent were subject to erosion. An estimated 41 percent included deep, fairly uniform soils, which could withstand considerable erosion while, with increasing inputs, continuing in cultivation. About 48 percent were deep soils with heavy subsoils, which, if eroded, would require shifts to much longer rotations, or to permanent pasture or woodland use. The remaining 11 percent were shallow soils over rock, hardpan, and claypan, upon which any considerable erosion would mean the virtual end of their use for cultivated crops.

To illustrate the effects of erosion on crop yield, Tables 30 and 31 indicate the relationship as it exists on some Corn Belt soils.

Table 30. Relation of Corn Yield to Depth of Surface Soil, Illinois 1/

Tama silt loam				Swygert silt loam			
Depth (inches)	Corn (bushels)	Depth (inches)	Yield (bushels)	Depth (inches)	Yield (bushels)	Depth (inches)	Yield (bushels)
12.8	93.3	13.3	79.8	13.0	70.4	14.0	56.1
10.6	75.8	11.0	88.8	9.5	68.8	10.0	44.7
8.0	71.6	8.5	77.0	7.7	57.5	6.5	29.7

1/ O'Dell, R. T. 1950. A study of sampling methods used in determining the productivity of Illinois soils. Jour. Agr. 42(7):17.

Table 31. Relation of Corn Yield to Depth of Surface Soil, Iowa 1/

Depth (inches)	Yield (bushels) Marshall silt loam	Tama silt loam	Shelby silt loam
11-12	119.9	63.9	--
9-10	109.0	58.1	--
7-8	92.7	45.8	49.8
5-6	79.6	42.8	45.2
3-4	65.4	38.4	38.9
1-2	52.3	31.8	35.1
0	--	--	24.7

1/ Uhland, R. E. 1949. Crop yields lowered by erosion. Soil Conservation Service, TP-75, p. 17.

The yield figures represent various outputs from comparable inputs. Yield effects of soil erosion are commonly masked, or even reversed, where increasing inputs are applied to eroding soils. Surprisingly high yields have been obtained from some badly eroded soils, 3/ but only where other inputs have been increased far above what would have been required for equivalent production from the uneroded soil. Thus, the true effects of erosion might be reflected more in cost of production, or in input-output ratios, than in physical yield values.

In total soil lost, the Southeastern States have suffered the most from soil erosion. The wide adoption of needed land-use adjustments, however, has reduced the rate of loss in that region. For the base period the greatest annual soil loss was in the Corn Belt, particularly in problem areas such as western Iowa where, in many fields, corn was grown almost continuously on long, unbroken slopes. For the country at large, about 80 percent of soil-erosion losses have occurred in the area east of the 100th meridian.

Soil Blowing

While few reliable figures are available on the areas affected by soil blowing (wind erosion), it may be assumed that over 100 million acres are subject to this type of loss, of which perhaps 10 million acres are seriously affected.

3/ Baver, L. D. 1950. How serious is soil erosion? Soil Science Soc. Amer. Proc. 15(1): 1-5.

The effects of such losses on crop yields are similar to those due to soil erosion by runoff water. The most fertile parts of the soil are removed, conveyed in the air for considerable distances, and then deposited on the land, in cities and towns, or in the sea. Much of the soil removed is redeposited on farmland, where it remains available for use. However, much of it is deposited where no use can be made of it or where it creates major problems of removal. The dust storms, which represent the more serious cases of soil blowing, cause additional damage through abrasive action on crops, machinery, and farm equipment.

Generally limited to arid and semiarid areas, losses from soil blowing are widely distributed, but have reached the greatest magnitude in the Dust Bowl of northwestern Texas, northeastern New Mexico, western Kansas and Oklahoma, and eastern Colorado. Soil blowing in the humid areas, although less serious, does create acute local problems, particularly on drained and cultivated organic soils (peat and muck) and on very sandy soils.

Deterioration of Soil Structure

While loss of favorable structure frequently accompanies soil erosion through the exposure of harsh, cloddy subsoils, it is also a widely prevalent consequence of cultivation even where no soil is lost. Yield reductions may be permanent in the absence of proper soil management, but generally the condition can be corrected through a shift to fewer and more careful cultivations and better rotations. Poor structure may develop at the surface (surface crusts), below the furrow slice (plow or tillage pans), or within the surface soil (puddling and compaction).

Hard surface crusts develop mainly from the beating of raindrops upon unprotected soil. Adverse effects on crops arise from (1) impeding of water infiltration with consequent increase in runoff and erosion, (2) interference with seedling emergence, and (3) injury to young plants upon cultivation.

Plowpan formation is a frequent result of overcultivation of moist, medium-textured soils with implements the blades of which tend to compact the soil immediately below the furrow slice. Plowpans affect crop yields through resistance to root development and reduction in permeability to water.

Puddling and compaction of the surface arise when soils are driven over or cultivated while still moist, with consequent reductions in yield from the unfavorable seedbed produced. The hoofs of grazing livestock may also cause some compaction.

Structure deterioration occurs in varying degrees throughout the country. The most severe damage to crop production is generally on the medium-textured soils, particularly silt loams,

but many areas of heavy soils are susceptible, such as the lake plain soils of northern Ohio. Damage is frequently less severe in regions where heavy frosts are common. Damage due to the formation of surface crusts is most pronounced in sandy loams and silt loams.

Alkali Accumulation

Soil deterioration from the accumulation of deleterious salts may follow the application of salty irrigation water, inadequate development of drainage, or both. It is limited largely to the irrigated areas of the 19 Western States. Particularly affected are the San Luis Valley of Colorado, the Lower Gila in Arizona, the Imperial Valley of California, and the Riverton and Kendrick projects of Wyoming. For the base period this irrigated region averaged about 22 million acres, of which 25 percent, or 5,500,000 acres, was materially affected and 10 percent, or 2,200,000 acres, was seriously affected. In addition to the chemical effects of toxic concentrations of salts, alkali accumulation frequently leads to deterioration in the physical structure of the soils, making them impermeable and untillable. It is usually accompanied by waterlogging of the soil. Unlike losses due to severe soil erosion, losses arising from alkali accumulation and waterlogging are generally reversible. Most of the affected areas could be reclaimed by improved drainage, application of water of lower salt content, if available, and the use of soil amendments, such as gypsum, or sulfur and lime.

Losses on Grazing and Forest Land

This report covers the 631 million acres of range and pasture, 320 million acres of forest range, and 257 million acres of ungrazed forest and woodland in the United States.

The most important causes of agricultural losses on grazing lands are wind and water erosion, overuse, the invasion of trees and shrubs, and drought.

Wind and water erosion have removed the topsoil over vast areas and caused a decline in both the quality and quantity of vegetation. Furthermore, the runoff and erosion debris from grazing lands has increased the destructiveness of floods and added to the silting problem of reservoirs and irrigation works.

Overuse has accompanied such soil erosion and, in fact, has frequently been the cause of it. This factor has seriously reduced the productivity of grazing lands over wide areas.

The invasion of trees and shrubs into new areas and the thickening up of existing stands have also reduced the production of usable forage on rangelands, and to a lesser extent on pasturelands. Estimates of the area seriously affected by such in-

vasions range from 80 to 168 million acres in the West, and as high as 240 million acres for the entire United States.

Drought, which normally occurs 3 years out of every 10 over great areas of rangeland, contributes to range depletion and increased production costs. Although commonly assumed to be nonpreventable, the effects of droughts on grazing lands can in fact be greatly reduced by the continued practice of good management.

All these causes of losses frequently operate on the same lands at the same time. For example, overuse may so open up the stand of herbaceous forage cover as to stimulate the thickening up of brush species. This process may be accentuated by drought, and, in turn, may accelerate wind and water erosion. The combined effects are a loss in productivity of the land, a reduction in taxable wealth, and lowered income.

Since their effects cannot be separated and no method is known by which their combined effects can be determined directly, such losses have been estimated by an indirect method. Briefly, this method is based on the extent to which production from grazing lands could be increased if all known and economically feasible measures of improvement were adopted, and on the assumption that the increase in income that could be expected from such improvement is a satisfactory measure of current losses.

The data presented in Table 32 indicate that the productive capacity of United States grazing lands can be more than doubled; such improvement would result in a 50-percent increase in the net income from these lands.

Table 32. Potential for Improvement of Grazing Lands in the United States

Classification of Land	Area	Improvement Potential: Percent of Present	Improvement Potential: Equivalent Acreage
	Million acres	Percent	Million acres
17 Western States			
Privately owned --			
Range and pasture	365	200	730
Forest range	74	150	111
Publicly owned --			
Range	215	300	645
Forest range	105	200	210
31 Eastern States			
Privately owned --			
Range and pasture	51	200	102
Forest range and pasture	61	125	76
Publicly owned --			
Forest range and pasture	80	125	100
Total	951		1,974

To attain full improvement would require the adoption of numerous conservation practices, including reseeding to improved range and pasture species to increase the forage and extend the grazing season; the eradication or control of noxious plants; additional fencing; a considerable increase in reservoirs, wells, and other water facilities to improve the distribution of livestock; increased use of fertilizers; and improved management. Existing technology and materials are adequate for the attainment of such goals.

Based on the current gross return from grazing lands, the net production is estimated to be worth $1.8 billion. A 50 percent increase in net income from these lands would be worth $900 million. About 20 percent of this increase could be obtained by preventing erosion. It is accordingly estimated that the loss from erosion on grazed pasture and rangelands can be given a conservative evaluation of $180 million.

On the assumption that the losses on nongrazed forest and woodland are approximately half those on grazed lands, the loss on the 257 million acres of such lands would amount to an additional $25 million.

Watershed Damage, Including Floodwater and Sediment

Floodwater and sediment take a heavy toll from agriculture in the United States each year. In terms of 1942-51 price levels, the annual loss to agriculture alone is estimated to be about $557 million. These losses include damage to crops and pasture; land damage in the form of flood-plain scour, streambank erosion, gullying, and valley trenching; loss due to infertile overwash or deposition of sediment and swamping; damage to farm buildings, fences, roads, stored crops, livestock, and irrigation and drainage facilities; and indirect losses, such as delays in field work and disruption or delays in marketing of farm products.

These damage estimates are presented in two parts — (1) those occurring upstream, or in tributary or headwaters of major rivers, and (2) those occurring downstream, or in major river valleys. In general, the term "upstream" refers to areas above existing, authorized, or proposed major flood-control structures, and "downstream" to areas below such structures. For the Nation as a whole, the annual upstream agricultural damage from floodwater and sediment amounts to about $391,774,000 (Tables 33 and 34). This constitutes the largest share of the total agricultural losses from floodwater and sediment, perhaps as much as 70 percent, primarily because flooding is much more frequent on small tributary streams. However, a large amount of protection has already been provided to major river valleys by levees and flood walls, channel improvements, and major reservoirs. Were it not for this protection downstream damage would be about 60

Table 33. Estimated Annual Upstream Agricultural Damage from Floodwater and Sediment in the United States, 1942-51 1/

Type of damage	Annual damage	
Floodwater:		
Crops and pasture	$205,694,000	
Flood plain scour, gully and valley trenching	31,468,000	
Other agricultural (farm buildings, stored crops, etc.)	73,059,000	
Sub-total		$310,221,000
Sediment:		
Infertile overwash	20,320,000	
Swamping	13,977,000	
Drainage and irrigation facilities	12,634,000	
Sub-total		46,931,000
Indirect (interruption of essential farm work, etc.)		34,622,000
Total		$391,774,000

1/ Estimates prepared by the Soil Conservation Service in 1952. These estimates were developed from intensive floodwater and sediment damage studies made by the Department over the last 15 years in 77 watersheds covering an area of about 52 percent of the continental United States. It should be understood that these are preliminary estimates derived from a large number of field investigations of varying degrees of reliability.

Table 34. Estimated Annual Upstream Agricultural Damage from Floodwater and Sediment in the United States by Geographic Areas, 1942-51

Area	Floodwater	Sediment	Indirect	Total
1	$ 7,896,000	$ 1,377,000	---	$ 9,273,000
2	180,768,000	14,949,000	$ 7,518,000	203,235,000
3	106,530,000	26,857,000	25,518,000	158,905,000
4	15,027,000	3,748,000	1,586,000	20,361,000
Total	$310,221,000	$46,931,000	$34,622,000	$391,774,000

Area 1	Area 2	Area 3	Area 4
Connecticut	Alabama	Illinois	Arizona
Delaware	Arkansas	Indiana	California
Maine	Florida	Iowa	Colorado
Maryland	Georgia	Kansas	Idaho
Massachusetts	Kentucky	Michigan	Nevada
New Hampshire	Louisiana	Minnesota	New Mexico
New Jersey	Mississippi	Missouri	Oregon
New York	North Carolina	Montana	Utah
Pennsylvania	Oklahoma	Nebraska	Washington
Rhode Island	South Carolina	North Dakota	
Vermont	Tennessee	Ohio	Alaska
West Virginia	Texas	South Dakota	Hawaii
	Virginia	Wisconsin	
	Puerto Rico	Wyoming	

percent greater than the estimated $165 million. From the information available it was not possible to present downstream losses by types of damage or geographic areas.

In the upstream areas damage to crops and pasture constitutes over 50 percent of the total, and other agricultural damage about 20 percent. Flood-plain damage by scour, streambank erosion, gullying and valley trenching, infertile overwash and swamping, though not so important monetary-wise, are important from the standpoint of our agricultural resources. At least 5 percent of our total agricultural land lies in the alluvial flood plains of tributary valleys. In general, this land is the most productive that we have. If given flood protection it will remain productive for a long time. Some land damage is temporary, as full productivity can be restored within a few years. On other land the damage is more nearly permanent, and productivity is impaired for future generations. Deposition of sediment may actually be beneficial to some bottomlands. However, this beneficial effect is slight in upstream areas.

Sediment damage occurs more often in cultivated farmland, especially in geographic areas 2 and 3 (Table 34). Lands under cultivation are usually most subject to washing and to other forces of erosion. Erosion contributes large amounts of sediment to the headwater tributaries and consequently to downstream areas. Such sediment fills channels, is deposited on the highly productive flood plains, and is carried into major reservoirs. Damages from sedimentation tend to be cumulative. Sediment that is brought down from the top of the hills into tributary and major valleys will cause damage in future years through decreasing the channel capacities, gradual destruction of the productive bottomland, and swamping of the bottomland with consequent raising of ground-water levels.

In most upstream tributary valleys, a large share of the total loss from floods is caused by short intensive storms which cover relatively small areas. Such storms occur far more often than do those of longer duration over large areas, which are required to produce a main stem flood. Because of the thousands of headwater streams that drain our vast agricultural regions, the damage caused each year by many frequent floods is enormous.

At 1951 prices, it is estimated that the annual agricultural and nonagricultural floodwater damage in the major river valleys is about $500 million. 4/ At 1942-51 prices the figure would be about $410 million, of which $165 million is agricultural damage. In addition, annual downstream sediment damage will approximate $28 to $30 million. These sediment damages, unlike those in the headwaters of streams, are predominately nonagricultural.

4/ Pick, Lewis A. 1952. Flood control. Military Eng. 44(301): 323.

Losses from Misuse of Water

In addition to the extensive losses from floods and sediment caused by water, there are significant losses of and to water as an agricultural resource. Much of the water responsible for flood and sediment damages represents badly needed moisture lost through runoff from improperly managed cropland, rangeland, and forest land. Losses also arise from wasteful storage, conveyance, and application of irrigation water, and from overpumping of ground water.

Irrigation Water

Of the approximately 100 million acre-feet of water annually diverted for irrigation, 50 million acre-feet were lost through seepage and evaporation in transit between the point of diversion (reservoir, stream, well) and the farm to be irrigated. Another 25 million acre-feet were lost between the margin of the field and delivery to the root zone of the crop. If only a third of the loss were prevented, the annual saving, at $2 per acre-foot, would amount to $50 million. The fact that only about 5 percent of the approximately 120,000 miles of canals and laterals are lined gives some indication of the scope of preventability of seepage losses.

Obviously, water lost from seepage does not represent a total loss, since much of it becomes part of the ground-water supply and, with additional inputs, remains available for use. On the other hand, water lost from canals, laterals, and irrigation checks and furrows is the major source of the waterlogging and contributes to alkali accumulation. In addition to these losses by seepage, evaporation, and runoff, millions of acre-feet of water are lost annually through transpiration of phreatophytes (water-consuming plants of little economic value).

Ground Water

The over-all ground-water resources of the Nation are not being significantly depleted, but in localized areas overdevelopment is a critical problem. Losses of ground water from overdevelopment primarily increase pumping costs, but if pumping exceeds recharge for a considerable time, reduced yields and, in some areas, abandonment are the ultimate results. In the southern San Joaquin Valley of California, for example, the annual overdraft on ground water is 1 to 1.5 million acre-feet. Although only part of the losses from overpumping are agricultural, over half of the estimated 20 billion gallons of ground water pumped per day is used for irrigation and other agricultural purposes. 5/

5/ McGuinness, C. L. 1951. The water situation in the United States, with special reference to ground water. U. S. Geol. Survey Cir. 114, p. 84.

Agricultural losses involving the quality of ground water arise principally in areas where overpumping has depressed the water table to the point where the supply has become contaminated by saline ground water, particularly sea water. In limited areas agricultural water supplies have become contaminated by brine from oil wells and by other industrial wastes. Where saline water has reached canals or pipes that supply irrigation or stock water wells, the operators must either reduce or cease pumping or install expensive recharge systems.

Whereas losses of irrigation water are limited largely to the irrigated areas of the arid West, losses from overdraft of ground water and encroachment of sea water also reach local importance in many humid areas. The comparatively humid State of Louisiana, for example, with heavy pumping for rice irrigation, has had more cases of failing ground-water supplies than has Nevada with the lowest precipitation and runoff of any State. Similarly, Florida, with 60 inches of annual rainfall, has had seriously depleted ground-water reserves, with the result that sea water has reached wells as far as 8 miles inland. In Florida, as in Louisiana, these losses are only partly agricultural. Other areas where ground-water depletion and saline encroachment are particular problems for both urban and agricultural use include Santa Ana, California, southern Arizona, southern Alabama, the southern high plains of Texas, and irrigated valleys such as the Rio Grande of Texas and New Mexico and the Central Valley of California.

CHAPTER XII. UNTABULATED LOSSES

American agriculture suffers many kinds of losses to which the Department cannot at present assign specific dollar values or acreage equivalents. They are accordingly not covered in the figures tabulated in this report. They include losses in nutritive values in food preparation, damage from the feeding of birds and wild game, labor and materials used in controlling pests, losses during the processing of most animal products, deterioration that shortens the period of usefulness of goods such as buildings, furniture, and fabrics manufactured from agricultural and forest products, and deterioration of farm machinery and other capital investment items. The general nature and extent of some of these kinds of losses are discussed in this chapter.

Losses of Food in Homes, Institutions, and Restaurants

The Nation's food supply provides approximately 3,200 calories per capita per day when measured as it enters the kitchen. Yet this is probably 700 to 800 calories more than is needed for actual ingestion. Some of the difference may be due to overeating, since a fair percentage of adults are overweight. A large part of the difference, however, is due to losses of food in the home or in institutions and restaurants.

There are three types of physical, or visible, losses:

(1) Excessive fat on meat that is discarded as kitchen trimmings, drippings from cooking, or as plate waste.

(2) Kitchen trimmings of fruits and vegetables which, had they been in perfect condition upon receipt, would have had only a minimum discarded as inedible; also excessive amounts of good-quality produce that were trimmed off owing to poor management practices.

(3) Other foods, a large proportion of which probably are grain products, that are discarded because of staleness or spoilage due to poor management practices or because they are left-overs, bread crusts, etc.

In addition to these losses, there are invisible, chemical losses in quality and nutritive value. Some losses in nutritive value are unavoidable during transport from farm to consumer and in the cooking of foods, but probably a large share could be avoided through education in household food-preparation practices and through better handling of fresh produce in wholesale and retail distribution.

Household Losses

The best estimate of visible food losses between the retail store and actual consumption in households is in terms of calories—15 percent. As much as two-thirds of this may come from fat on meat. Although some of the drippings are reused for frying and baking, much is probably discarded along with separable fat from roasts, chops, and steaks. Since pure fat has over twice as many calories per ounce as carbohydrate or protein, losses of fat have a heavy weight in calculation of calorie loss.

Losses in terms of protein and of minerals are lower than for calories. According to current estimates, as much as 10 percent of the protein that enters the kitchen may not be consumed, and 7 percent of the calcium. Losses of vitamins because of physical loss of foods may average 5 percent.

All these estimates are rough and are based upon indirect evidence. Examples of the more common types of physical losses are: Separable fat from meat discarded as plate waste, fat drippings discarded, containers broken and foods spilled, foods wasted (from children's plates especially), fresh fruits and vegetables kept too long and spoiled, sugar left in coffee cups, bread becoming stale, toast burned, crusts not eaten, and insect infestation of cereals. Foods fed to animals may not be considered a complete loss, but they account for some of the differences between food available for consumption and that actually eaten by people.

Current estimates of invisible chemical losses of four vitamins from cooking and other preparation practices, such as storage of leftovers, are as follows: Thiamine, 20 percent; riboflavin, 5 percent; niacin, 15 percent; and ascorbic acid, 30 percent. These estimates are in addition to losses in these vitamins when the foods themselves are discarded.

Losses of vitamins take place from the time foods are harvested until they are eaten. Those that occur in the home may also be affected by the treatment of foods in marketing, since preparation losses are increased by handling that damages the tissue. In the kitchen vegetables and fruits may lose nutritive value during preparation for cooking or for serving in the raw state. The frequently discarded outside leaves of lettuce and broccoli, for example, contain more minerals and vitamins than the inner parts. Cutting and shredding of vegetables expose new surface to the air and allow greater oxidation and consequently loss of vitamin C. Losses of vitamins in cooking depend chiefly on the volume of water used, the amount of food surface exposed, and the length of the cooking period. With larger amounts of water more of the water-soluble vitamins and minerals are leached out.

The greater the surface exposed to the cooking water, the more opportunity there is both for leaching and for destruction by oxidation. Finally, longer cooking periods and higher temperature cause greater vitamin destruction.

Losses in Institutions and Restaurants

No estimate has yet been made of losses of food in the Nation's institutions (including hospitals) and restaurants because of the paucity of basic data. Approximately one-sixth of our civilian food supply is disposed of through nonfamily consumption. The judgment of most food-consumption analysts probably would be that losses in restaurants are higher than in homes. Institutions vary so much in type, personnel, and resources that it is difficult even to guess whether food loss is higher or lower than in homes.

Depredations of Game and Birds

Damage to agricultural crops by wildlife cannot be estimated accurately. Many of the data available concern reports on losses suffered by individual farmers and others, with no indication of their frequency or extent, and the reliability of many of the figures is questionable. Monetary damage claimed is often exaggerated, and rarely is consideration given to the simultaneous indirect benefits resulting from the presence of birds and mammals in agricultural areas.

Tremendous numbers of harmful insects and large quantities of weed seeds are consumed by game birds and some species of field rodents. Undoubtedly such beneficial effects often offset losses due to direct injury to agricultural crops. Game birds and animals constitute a natural resource, the annual harvest of which is valued at many millions of dollars by sportsmen. Therefore, any attempt to ascertain the net damage caused by wildlife should take these other values into consideration.

Game Animals

Information concerning damage caused by big game such as deer, elk, and antelope is too incomplete for even a rough estimate. These animals occasionally cause damage to hay, grain, garden crops, and orchards. In many States the farmer is compensated for such loss by the game and fish departments. For instance, in Colorado these payments totaled over $68,000 over the 3-year period 1950, 1951, and 1952. The salary and expenses of game department personnel employed in management of game species involved an additional $120,000. The State also spent $114,000 on emergency feeding, fencing, and controlling the animals. Thus a total of over $302,000 could be charged to big-game animals in that one State for the 3-year period.

Significant damage undoubtedly occurs in 15 or 20 other States that have large populations of big game. The total may be several million dollars. However, when measured in proportion to the value of all agriculture commodities produced, it would only constitute a very small fraction of one percent. For this reason and also because of values of these species as game, the Fish and Wildlife Service believes that net damage by big game is too small a factor to warrant inclusion in the report totals.

Damage by Birds

In recent years considerable attention has been focused on damage caused by migratory birds. The damage reported runs the gamut from scoter predations on scallop beds to woodpecker damage to powerline poles. However, of major concern to the American farmer are crop losses caused by ducks, geese, coots, and blackbirds. Bird depredations occur in at least 20 States. The amount of damage varies from year to year, reaching serious proportions in certain areas about 3 years out of 10. Thus far most of the crop losses have been reported in North and South Dakota and California. In the Dakotas the problem concerns primarily fall populations of migrating ducks, whereas in California the losses are charged to wintering populations of birds. In all three States, however, the farming practices lend themselves to depredations. This is especially true in North and South Dakota, where much of the wheat crop is swathed before it is combined.

Crop losses through migratory-bird depredations can be likened to crop losses from floods. If one farms in a river valley, he knows that the flood hazard is present during certain periods of the year. If one swathes down small grain in parts of North Dakota, he must also recognize that a depredation hazard is present. Generally speaking, however, crops lost to migratory birds throughout the United States are minor compared with the total production, although such losses are important to the individual farmer.

The Branch of Game Management within the Fish and Wildlife Service is charged with the responsibility of aiding property owners in reducing losses caused by birds, and expends approximately $65,000 per year for that purpose. Included in this figure are salaries and expenses of personnel assigned to depredation-control work, plus the cost of pyrotechnics and other scaring devices purchased for use during the year. Thus far the cost for firearms and pyrotechnics used in the program has been slight, inasmuch as surplus military weapons, flares, and simulated grenades have been made available for such use by the Armed Forces. In addition to these funds, the Branch of Wildlife Refuges expends between $300,000 and $400,000 per year in the production of migratory-bird foods to alleviate depredations.

Losses Due to Mosquitoes and Biting Midges

Mosquitoes are an important problem to the farmer, his family, and employees in many parts of the United States, but especially in the irrigated areas of the Western States. The large farm populations in the older irrigated areas in Oregon, Idaho, Utah, Montana, Nevada, Arizona, Colorado, and several midwestern and eastern States suffer from mosquitoes.

Mosquitoes and related biting midges cost the farmer money. His employees are much less efficient during the mosquito season because of the annoyance of these pests. Some employees even leave the farm because of these biting insects. Moreover, the farmer and his family are prevented from enjoying their yard and outdoor living during the mosquito season.

The problem is increasing because of the extensive change from crop production to irrigated pastures in the last few years. The acreage under irrigation in the United States increased 43.4 percent from 1939 to 1949, 1/ and substantial parts of the newly irrigated areas are in pastures. Such pastures are ideal breeding areas for several species of mosquitoes. California has 235,000 planted acres in irrigated pasture in 1940 and more than 730,000 acres in 1952. Approximately 3,000,000 acres of cropland in this State produce mosquitoes. Over 1,000,000 new acres are being placed under irrigation in the State of Washington by the use of water from behind the Grand Coulee Dam.

There has also been a great increase in pasture acreage in the South. Georgia had 900,000 acres in grassland crops in 1925 and 6,000,000 acres in 1952. Goals set up by county agricultural mobilization committees provided for the improvement of 169,000,000 acres of grassland crops in various ways, including

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1/ Agricultural Census 1950. Vol. 3, Irrigation of Agricultural Lands, p. 35, Table 2.

irrigation, in 1952-53. Pastures and grasslands need not be irrigated to produce mosquitoes, since in some places sufficient rainfall accumulates in low places to produce the pests. Pastures and grasslands are better suited for mosquito production than other croplands.

Mosquito and midge problems also arise from water impounded by dams. For example, a costly mosquito-control program is necessary in the TVA impounded waters.

In some areas mosquitoes are becoming resistant to DDT and related materials, and it is expected that such difficulties will increase.

Besides being pests, mosquitoes also transmit diseases. The most important in the West is encephalitis. Malaria has been nearly stamped out in the Southern States, but at one time it reduced the effectiveness of farmers and prevented the use of good agricultural lands.

Costs of Controlling Losses

Insects

In addition to reducing the quantity and quality of crops, livestock, and other agricultural products, insects increase the costs of production because of the necessity of applying measures for their control. Not only the producer, but also the processor or packer, the shipper, the warehouseman, and the ultimate consumer are affected. Insect control on farms, in households, and elsewhere costs about $400,000,000 per year in this country.

These costs may be grouped under five major categories - (1) insecticidal control, (2) cultural and mechanical practices, (3) biological control measures, (4) large-scale cooperative control programs, and (5) enforcing and conforming to quarantines and regulatory measures.

The control measures required are developed by research conducted by Federal and State agencies and by industry. The cost of this research is not included in the estimates.

Insecticidal Control. - The annual cost of all insecticides used in this country during the period 1942-51 is estimated at $195,000,000. The cost of applying insecticides, including the cost and depreciation of equipment, is about 94 percent of the cost of the insecticides, or $180,000,000. Thus the total annual cost of controlling insects with insecticides is about $375,000,000.

The availability of new insecticides, beginning with DDT which was released to the public in 1945, has made the estimating of

costs of application very difficult. Constantly changing formulations as well as methods of application have completely revolutionized the methods used. In the control of cotton insects, prior to 1946 the principal insecticides were calcium arsenate and sulfur, but during the period 1946-51 DDT, BHC, and sulfur predominated, although a number of other new insecticides were being introduced. Similar changes have been made on other crops and commodities.

The cost of application of insecticides was evaluated in relation to the cost of the insecticides rather than on an acreage basis. About one-fourth of all insecticides used were on cotton, and it cost about 40 cents to apply a dollar's worth. Fruit and cereal and forage crops required about one-fourth of all insecticides used, and the cost of application to these crops was about half the cost of the insecticides. The remaining insecticides were used under situations that called for higher application costs. On vegetables, greenhouse crops, stored products, livestock pests, and in the home, the cost of application was estimated to be nearly one and one-half times the cost of the insecticides.

Cultural Control. - No data are available for estimating the amount expended for controlling insects by cultural or mechanical methods. Some of the cultural practices used by the grower are clean cultivation, stalk and trash destruction, crop rotation, planting resistant varieties, hand picking or hand worming, timing of planting dates, and screening. After harvest many products require special handling and grading to make allowance for insect damage and special storage or packaging to prevent infestation. These practices add an appreciable amount to the cost of insect control.

Biological Control. - The expense of utilizing natural enemies such as parasites, predators, and diseases as a means of combating insects is borne chiefly by Federal and State agencies. In only a few instances-such as lady beetles for use against mealybugs and certain scale insects on citrus, the parasite *Macrocentrus ancylivorus* against the oriental fruit moth on peach, and milky disease spore dust against the grub of the Japanese beetle - have these biological agents been available commercially for use by private individuals. At least $500,000 is expended annually in the biological control of insect pests, including the search for beneficial insects in foreign areas and importing them into the United States.

Plant Diseases

The production of a number of agricultural crops, particularly fruits and vegetables, requires spraying or dusting with fungicides for disease control. The production of apples, peaches, cherries, and certain vegetables in the humid sections of the country is impossible without protectant fungicides. Most of

the seed of small-grain crops is treated with a fungicide before planting to protect against soil-borne organisms and certain other fungus diseases. Most of the potato crop is now planted with certified seed, which is much more expensive to produce than is ordinary table stock. Soil fumigation is practiced when valuable crops are to be grown in soil heavily infested with nematodes. Several plant diseases that are the subject of publicly financed control programs are later referred to in the discussion of cooperative control programs.

The following estimates are for the annual expenditure by private companies and individuals for fungicides, for labor to apply them, and for depreciation on machinery required for their application:

	Million dollars
Spraying and dusting, mainly of fruit and vegetable crops..............................	$ 72
Chemical treatment of seed, mainly grain crops....................................	14
Production of disease-free planting material, mainly certified potato seed..........	24
Soil fumigation, mainly for nematode control..................................	8
Total..............	$118

Cooperative Control Programs

Under specific legislation the U. S. Department of Agriculture cooperates with the States in certain extensive insect and plant disease control and regulatory programs. Current programs can be classified into three categories as follows:

(1) Eradication of incipient infestations of introduced agricultural pests. The only such program currently in operation is the one on the eradication of the Hall scale, a serious pest of stone fruits.

(2) Prevention of spread of destructive pests of foreign origin that have become established in limited areas in this country. Regulatory programs are being carried on to prevent the spread of the golden nematode, gypsy moth, Mexican fruit fly, Japanese beetle, phony peach, peach mosaic, pink bollworm, sweetpotato weevil, and white-fringed beetle. Pests that are confined to limited areas by cooperative control and regulatory action do not normally cause the tremendous losses that would occur if they were distributed over their entire ecological range.

(3) Suppression of widely distributed insects and plant diseases that assume outbreak proportions periodically, causing extensive interstate agricultural losses, and that cannot be controlled effectively by individual effort. Currently such programs relate to grasshoppers, Mormon crickets, stem rust, white pine blister rust, and various forest insects, especially bark beetles and defoliators. Each year Federal, State, and private groups spend considerable amounts to prevent the spread of these insect pests and plant diseases and to suppress outbreaks.

During the fiscal year 1950 approximately $10,000,000 was expended from Federal sources for cooperative regulatory and suppression programs, including over $3,000,000 to suppress outbreaks of forest insects alone. State and local agencies were reported to have spent over $13,000,000 on these programs.

Quarantine and Regulatory Measures

The enforcement of quarantines affecting the importation and interstate movement of plants and plant products cost approximately $3,650,000 annually during the period 1942-51. This estimate includes (1) Federal appropriations for plant quarantines; (2) contributions by States and Territories, particularly California, Florida, Hawaii, and Puerto Rico, to the plant-quarantine program; and (3) costs to importers in connection with the inspection, treatment, cooperage, handling, and other incidentals to meet plant-quarantine import requirements. The expense of fumigating or otherwise treating large quantities of imported cotton and cotton products, broomcorn, fruits and vegetables, and used bagging, is included in the last group.

Weeds

The annual cost of weed control on agricultural lands has been estimated at $1,486,351,000, or about 8 percent of the value of the crops produced on cropland and farm pastures (Table 10). This is equivalent to approximately $1.08 per acre of crop, pasture, and range lands.

CHAPTER XIII. SUMMARY

Agriculture is subject to numerous causes of loss. Weather, plant and animal diseases, insects, and weeds are among the great natural hazards of crop and livestock production. Weather is perhaps the chief one, since not only do droughts cause crop failure, but excessive rainfall results in soil erosion and floods. All our agricultural crops are subject to diseases, some of which cause enormous losses. Insects reduce the yield and lower the quality of crops, increase the cost of production and harvesting, and require cash outlays for materials and equipment for control measures. Insects also destroy or reduce the quality of many agricultural products in storage. Birds and wild game feed on growing crops. Many of our forest trees are subject to disease and insect depredations, which sometimes destroy vast areas of mature timber. The production of food, feed, and fiber crops is made difficult by the losses from weeds. A major problem in livestock production is keeping animals healthy. Losses occur to crops and livestock and their products in the course of marketing and processing. Finally, calories and other food values disappear in the kitchen with the discard of edible portions of food or the destruction of nutrients in cooking.

The factors responsible for losses in agriculture have two kinds of economic effects. They increase the cost of production, and they reduce the quantity and quality of the products. Because of the lower production, more land and labor must be used to provide our requirements. With the same resources and cost expenditures, consumer needs would be more fully satisfied and better nutrition provided if the causes of loss were not present.

Recently an attempt has been made to assemble the information available on the various types of losses to the soil, agricultural crops (food, feed, and fiber), and livestock for the period 1942-51. These estimates are given as loss in value and the acreages that would have been saved if the loss had not occurred (acreage equivalents).

The estimates evaluate the crop production and land resources lost, at the prevailing average farm prices. This does not necessarily mean that the farmers' cash income would have been increased to the extent indicated if the losses had not been incurred. Increased supplies sometimes cause sufficient price decreases so that the total farm income may be no greater from a large crop than from a small one. However, the use of land, labor, equipment, and supplies in producing commodities that are later lost represents economic loss both to the farmer and to the Nation. The destruction of food supplies is just as serious from the standpoint of the American public whether or

not price changes result. The loss of value may be even more serious to the general public than to the farmer. It would not be possible immediately to sell greatly increased quantities of products except at lower prices, but in the next 25 years markets can be expected to expand considerably with continued population growth accompanying general economic growth. The Bureau of the Census now estimates an increase of 25 to 40 percent in the United States population by 1975 over that in 1953. Economical ways of meeting the requirements of a rapidly growing population must be found.

A summary of the losses in agriculture is presented in Table 35. The estimates given in this and other tables in the report are conservative and incomplete, and most of them are tentative; many are judgment estimates based on admittedly limited information.

Losses to crops during production due to insects and diseases, mechanical damage, hail, weeds, and inadequate harvesting amount to about $8.3 billion annually in value of products lost. These losses constitute 20 percent of the potential production ($41 billion) of all farms and forest growth. They are equivalent to the potential production from nearly 88 million acres. Our average harvested cropland was nearly 358 million acres.

Diseases reduce the total value of crops by $2.8 billion, or about 7 percent of the potential production of all farms and forest growth. Insects cause a loss of nearly $2 billion in the value of crops, or about 5 percent of the potential production. Losses due to mechanical damage, hail, and weeds reduce the value of crops by $2.4 billion, or about 6 percent of the potential production. Losses and waste during harvesting amount to $1.1 billion, or about 3 percent of the potential production.

Pasture and range lands are subject to various hazards, including plant diseases, fire, grasshoppers, and weeds. Losses from such hazards, first in the form of feed and eventually in reduced numbers and weight of livestock, amount to $981 million annually, or 2 percent of the total value of the Nation's farm and forest products. This is about 17 percent of the value of the potential pasture and range production. These losses equal the potential production of nearly 154 million acres. Livestock losses charged to pasture and range are equivalent to the potential production of 126 million acres additional. The total acreage of these lands was 1,020 million.

After crops are produced, they are subject to losses in storage, marketing, and processing, and in the sickness and death of some of the livestock to which they are fed. Rodents and rots destroy $382 million worth of stored crops, and insects reduce values

Table 35. Estimated Losses to Agricultural Production from Various Hazards (Average Annual Estimates for 1942-51)--Summary

Item and Cause of Loss	Loss in Value: Amount	Loss in Value: Percentage of: Potential 1/	Acreage Equivalent of Losses: Cropland 2/	Acreage Equivalent of Losses: Pastures and Ranges 3/	Acreage Equivalent of Losses: Forest Land 4/
	Million dollars	Percent	1,000 Acres	1,000 Acres	1,000 Acres
Crops and Livestock					
During production of crops, pastures, and ranges					
Diseases of crops	2,847	6.9	30,041	--	--
Insects attacking crops	1,942 5/	4.7	20,492	--	--
Mechanical damage, hail, and weeds	2,413	5.9	25,462	--	--
Harvesting losses	1,098	2.7	11,586	--	--
Subtotals	8,300	20.2	87,581	--	--
Pastures and ranges (diseases, fire, grass-hoppers, and weeds)	981	2.4	--	153,894	--
LOSSES DURING PRODUCTION OF CROPS, PASTURES, AND RANGES	9,281	22.6	87,581	153,894	--
After production of crops, pastures, and ranges					
Farm storage losses (other than from insects)	382	0.9	4,031	--	--
Storage losses from insects	217	0.5	2,290	--	--
Crop losses during marketing	303	0.7	3,197	--	--
Losses during processing of crops	271	0.7	2,860	--	--
Livestock, poultry, and their products (diseases, parasites, and insects)	2,688	6.6	19,859	126,441	--
LOSSES AFTER PRODUCTION OF CROPS, PASTURES, AND RANGES	3,861	9.4	32,236	126,441	--
TOTAL LOSSES TO CROPS, PASTURES, RANGES, LIVESTOCK AND PRODUCTS	13,142	32.0	119,816	280,335	--
Forest resources	284	0.7 6/	--	--	226,930 6/
Shade tree diseases and insects	141	0.3	--	--	--
Soil (deterioration losses and flood damage)	1,512 7/	--	--	--	--

1/ Except as noted, the percentage figures represent losses from potential production, in other words, actual production ($27.6 billion) plus estimated loss ($13.4 billion), a total of $41.0 billion. This is the value of crops, livestock, and forest products that would have been produced if the losses had not occurred.

2/ The acreage equivalents of those losses that are ascribed to cropland were based on a United States total harvested acreage of 357,835,000 acres. For the method of computation, see Chapters III and X. In the case of both the production and loss figures for livestock and poultry, 70 percent is attributed to cropland and 30 percent to pasture and range. The potential cropland production value was $33.9 billion.

3/ Based on a United States total of 1,020 million acres of pasture and range, the actual value of the production of pasture and range was $4,715 million and the potential production value was $6,502 million. (4,715 + 981 + (0.3 x 2,688) = 6,502)

4/ Based on a United States total of 460 million acres of forest lands.

5/ The value of $1,942 million in this table includes crop losses of $991 million from about 75 insects on which detailed estimates were made. Using that as a sample, it is estimated that the loss from the remaining several thousand species attacking United States crops was $951 million. Total losses to crops, livestock, forests, fabrics, households, and buildings from all insects have been estimated at $3,600 million and the cost of control measures at $400 million.

6/ The total forest annual growth was valued at $318 million on the stump on 460 million acres of forest land. This does not include the very substantial values added during cutting and manufacture. The loss was 49 percent of the potential annual forest growth, but less than 1 percent of the total potential production of crops, pasture, range, livestock, and forest. The losses tabulated do not include losses to forest products. The acreage equivalent was based on lost volume of annual growth.

7/ The loss from soil deterioration on cropland was $750 million in value of land. $205 million additional loss arose from soil erosion on grazing lands and forest lands, and $557 million from floodwater and sediments on watersheds.

by $217 million. Marketing losses amount to $303 million, and processing losses to $271 million. Diseases, parasites, and insects cause a reduction of $2,688 million in the value of livestock and poultry and their products. This amounts to about 14 percent of the total value of such products, over 6 percent of the total farm and forest production. These postharvest losses total about $3.9 billion and are equivalent to the potential production on over 32 million acres. The total preharvest and postharvest losses on cropland are equivalent to the potential production on almost 120 million acres.

Losses in our forest resources amount to $284 million, or 49 percent of the potential annual growth on the stump. These losses are caused by fire, diseases, insects, wind, and miscellaneous damage to trees. They equal a potential production from over 226 million acres of forest land, or nearly 1 percent of the total potential farm and forest production. The total acreage of forest lands is 460 million acres.

The diseases and insects attacking shade trees are estimated to cause $141 million damage.

Soil-deterioration losses and flood damage on croplands, ranges, and watersheds amount to an estimated $1,512 million, in terms of the effect upon the value of the land. On croplands soil deterioration, principally soil erosion, causes an annual loss of $750 million, partly from rendering 500,000 acres of cropland unfit for cultivation, but more significantly through the reduction of productivity and increase in production costs on cropland that remains in cultivation.

Nearly 120 million fewer acres of cropland, exclusive of pasture and range, would have produced the 1942-51 volume of food, feed, and fiber production, if all causes of loss had been eliminated. If full production could be attained on the acres lost because of hazards to crops and livestock, we could expect to raise more than sufficient food, feed, and fiber for the increased population anticipated by 1975. However, full production on these acres cannot be expected.

The extent to which losses in agriculture can be prevented through the utilization of known technical information has not been examined in a comprehensive manner. However, several specific hazards are analyzed in the report. Losses from diseases of cotton could be reduced by about 75 percent, from apple diseases and from potato diseases about one-half, and from the diseases of wheat about 23 percent, if all producers would use recommended control procedures, and if weather permitted their efficient use.

In the case of animals, about one-third of the losses from insect infestation, 90 percent of the losses from some poultry parasites, and all loss from brucellosis in livestock could be prevented by the widespread application of known control measures.

New research is continually needed to develop ways of producing larger quantities of food, feed, fiber, livestock, and forest trees at lower costs per unit of production, of cutting down waste and spoilage in products during handling, marketing, and distribution, and of making improved utilization of all agricultural products and byproducts.

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